

THE KD  
**Sea-man's Practice,**  
CONTAINING  
A Fundamental Problem  
IN  
NAVIGATION,  
EXPERIMENTALLY VERIFIED:

NAMELY,

Touching the Compass of the EARTH and SEA,  
and the Quantity of a Degree in our *English* Measures.

ALSO

An exact Method or Form of keeping a Reckoning at SEA  
in any kind or manner of Sailing.

With certain TABLES and other *Rules* used in *Navigation*.  
As also the *Plotting* and *Surveying* of *Places*: The *Latitude* of the  
Principal Places in *ENGLAND*: The finding of *Currents*  
at Sea, and what Allowance is to be given in respect of them.

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By RICHARD NORWOOD, Reader of the *Mathematicks*.

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# T O T H E R E A D E R.

**T**H E Circuit of the Earth and Sea (as the Circumference of every Circle) contains 360 Degrees, by which Degrees the distances thereon are measured, so that the knowledge of the quantity of such a Degree in our known Measures, is a fundamental Principle in Cosmography and Navigation, as upon which is grounded the Reckoning of the Ship's way, or distance run. For though a Mariner, being in his Voyage on the vast Ocean, hath sometimes three things to certify him where he is, and how to shape his Course to his desired Port, namely, his Latitude, Course, and Distance; and sometimes a fourth, namely, some near conjecture of his Longitude by the Variation, or otherwise; yet oftentimes (as in close Weather) he hath nothing but his Course and Distance; otherwise only his Latitude and Distance is his chief Guide in falling in with his intended Port. I know it is usual to allow near 7 Fathoms, or  $41\frac{2}{3}$  Feet to a Knot, and so many of those Knots as run out in half a Minute, so many Miles they account the Ship's way to be in an hour. And if in half a minute she run  $41\frac{2}{3}$  Feet; then in 60 min. or an hour, she runs 5000 Feet; and thus they account 5000 English Feet, or 1000 Paces, to be a Mile, and 60 of those Miles to be a Degree, such as the whole Circumference in any great Circle is 360. But how is this known to be true? If it be answered, that it is known to be so by Experience: then I would know further by what Experiment this was found to be so? Where, and by whom made? I press this so much the rather, because I am persuaded we have at this day as many excellent Navigators in this Kingdom, and as great Voyages performed, as from any other place in the World; and I should be glad to hear of the experimental Resolution of this Problem by some of them, though it were but in running 8 or 10 degrees near the Meridian: for so I doubt not but that which I have here written thereof, would receive farther Confirmation, and better Entertainment, then haply it will now, being so much different from the common Opinion; and the Arts of Navigation and Cosmography, would be much more perfected in a short time. For one Error (as a fruitful Mother) is oftentimes the cause of more; and the removing of one is the occasion of removing others, especially when they do mutually support one another. As we shall here shew how the Error in the projection and use of the common Sea-Chart, is supposed by this Error of accounting only 300000 of our Feet to a Degree; and this in like sort upheld by that, so that they will stand or fall together. And surely that had fallen long since, being so manifestly convinced, if it had not been upheld by this. For the confuting of that (I mean the common Sea-Chart) it was sufficient to know that the Earth and Sea make one Spherical Body. But in disproving and rectifying this, it is necessary to know moreover what is the quantity of that Spherical Body. And to that end, it was necessary to make a sensible application of our known Measures to a determined part of the



## To the Reader.

whole, that so the quantity of that determined part being known, and the proportion thereof to the whole, the quantity of the whole might also be discovered. And this I have endeavoured in the Experiment following, which if I have not handled so exactly in all points as some would desire (that requiring more Time and Charge than I could well bestow) yet I doubt not but it will be found that I have come very near the Truth. Some happily will censure me, for being my self at the Expence to make such an Experiment. But I was as frugal in it as I could, adding Pains and Industry to save Expence; I came up in ten or eleven days, and had other necessary occasions to lead me from one place to the other, and did this as a thing falling opportunely in my way: But indeed (as in all other parts of Learning) so in the Mathematicks, especially in their application, or middle Mathematicks (as some call them) it is necessary with Speculation, to joyn actual and experimental Practices; the former being empty and uncertain without these. It is true, that the Mathematicks afford large Fields of delightful Speculations, wherein a Man might walk far with much pleasure: But if from so many fair Flowers, he bring home no Honey, or from such large Fields no Sheaves; I mean, if he bring not these Speculations to some useful Practices, neither himself nor others are like to receive much Fruit by them. But this indeed cannot be effected without more Labour and Difficulty; yea sometimes it requires mechanical and bodily Exercises, which some esteem too mean and unworthy to stoop unto. But for mine own part, I acknowledge to have had my Living and Maintenance by the Mathematicks, and not by Speculation only, but rather by my Practice therein; and therefore also I desire what in me lies to make them fruitful to my self and others; and to that end have spent in some principal parts of the Mathematicks, near as much time and means in experimental Practices and Conclusions, as in the Speculations. Moreover, considering that this particular Experiment was proposed above 30 Years since, by our Country-man Mr. Edward Wright, to invite some to the tryal of it, as a thing which he would have done himself, if he had found such furtherance and opportunity as he desired, which it seems he did not, nor any other since that time. Rather than so noble and so necessary a Problem should longer rest unresolved, I took the opportunity offered, hoping it may be an occasion to whet on some others to do the like. This with some other things which I conceived to be wanting in the practice of Navigation, I have handled in this ensuing Treatise, which I commend to your friendly Acceptance. Farewel.

July the first, 1636.

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THE



T H E

# Sea-man's Practice.

C H A P. I.

*The common Opinion touching the Compass of the Earth, and  
Quantity of a Degree of the same.*

**I**T is a common received Opinion in *England* (and the like is in other places) that allowing 5 of our *English* Feet to a Geometrical Pace; a thousand of those Paces make an *Italian* Mile, and 60 of those Miles in any great Circle, upon the Spherical Surface of the Earth and Sea, make a Degree: and thus it is supposed, that a Degree contains 60 Miles; or 60000 Paces, or 300000 of our *English* Feet, and by such Miles do Mariners in their Voyages by Sea keep their Reckonings. And because the whole Circumference of a Circle is 360 Degrees; therefore the Compass of the Earth, according to this Opinion, should be 21600 such *Italian* Miles, or 2160000 Paces, or 108000000 of our *English* Feet. Whence this Opinion came, or upon what Experiment it should be grounded, I cannot certainly say: It may seem to be taken, or rather mistaken, from *Ptolemy*, who saith, there are 500 *Stadia* in a Degree; the same was before affirmed by *Marinus Tyrius*, of whom *Ptolemy* speaking in the 11th Chapter of his first Book of *Geography*; hath these words, *Sed in hoc quoque rectè sentit, partem unam qualium est Circulus Maximus tricentorum sexaginta, quingenta in terra constituere Stadia, id enim confessis dimensionibus consonum existit.* Now a *Stadium* not only amongst the *Greeks*, but as appears by *Herodotus*, amongst all other Nations of *Asia*, and in *Egypt*, did consist of 600 Feet, or 100 *Orgay's*, an *Orgay* containing 6 Feet, or 4 Cubits, as our *Bathom* is; the same also is testified by *Suidas* and others: So that a

Degree



Degree containing 500 *Stadiums*, and every *Stadium* 600 Feet, it follows that a Degree must contain 300000 Feet, exactly agreeing in number with the common received Opinion in *England*, which therefore may seem to be hence derived; and would also receive much Confirmation hereby (he being an Author of such approved Credit) if it could be approved that our *English* Feet were exactly equal to the *Egyptian* or *Alexandrian* Foot, where *Ptolomy* wrote. Otherwise that being true, that so many of their Feet make a Degree, it will follow, that if ours be greater, there be fewer of them contained in a Degree; if lesser (as undoubtedly they are) there must be more of them contained in a Degree.

*Philander*, in his Commentary upon the third Chapter of the third Book of *Vitruvius*, hath expressed the quantity of the ancient *Roman* Foot, where (by a competent allowance for the shrinking of the Paper, being printed wet) it may probably be gathered that it was something longer than our *English* Foot. But the *Alexandrian* and *Egyptian* Foot was much greater: for, according to *Hero Mechanicus*, 5 *Alexandrian* Feet were equal to 6 *Roman* Feet: seeing the ancient *Roman* Foot was something greater than ours, the *Alexandrian* must needs be much greater than ours. So that whereas *Ptolomy* saith, there are 500 *Stadiums* in a Degree; and, as we have shewed, a *Stadium* did consist of 600 Feet, these being *Egyptian* or *Alexandrian* Feet, as it is most probable, being the place where *Ptolomy* lived; there must be a far greater number of our Feet in a *Stadium*, and so in a Degree: whence it is evident, that there is no sufficient footing for this common Opinion in the Assertion of *Ptolomy*.

Neither doth the Practice and Experiment of Mariners in their Voyages at Sea prove it; for there is no Reckoning or Experiment at Sea set down by any (that I have seen) to confirm it. And tho it be true, that in sailing between two places that lie near to one, and the same Parallel, they ground their Reckoning chiefly upon this Supposition, that 300000 of our *English* Feet make a Degree, yet can they seldom or never by those Reckonings discern the Error, the rather for that they have been, and for the most part are still kept upon the plain or common *Sea Chart*, which makes a Degree in any Parallel equal to a Degree in the Equinoctial, and so makes a Degree in any Parallel to contain 300000 Feet: And it is true, that in some Parallel a Degree doth contain only 300000 of our *English* Feet; namely, about that parallel which is in Latitude 35 deg. (as we shall further shew hereafter) near unto which have the principal of our Eastern and Western Voyages been made. And thus, tho this opinion of 300000 Feet in a Degree, and



and the Projection of the common *Chart*, be both erroneous; yet, because the Error of the one doth something salve the other, they could not be so easily discern'd by Experience only.

This opinion of 300000 English Feet to a Degree, may seem also to be something confirmed by an Observation made by our Countryman Mr. *Edward Wright*, upon Mount *Edgcomb* near *Plymouth*, of the Semidiameter of the Earth, which he hath set down in his Book, *Of the Correction of Errors in Navigation*, Chap. 15. where he finds the Semidiameter to be 18312621 of our English Feet: whence it may be gathered, that in a Degree of a great Circle of the Earth, there should not be full out 320000 of our Feet. But the way by him then used, tho it was very fit for the end whereunto he there applies it; namely, to find the dipping or depressing of the apparent Horizon beneath the true, according to the height of the Eye above the Water; yet will it easily be granted to be no exact way for finding the Semidiameter, and consequently the Circumference of the Earth, or the quantity of a Degree on the same; and so he says there, that he used that way, because he wanted opportunity to put in practice a more exact way. Wherefore, for the further satisfaction of my self and others in this Point, and chiefly for the necessary use it hath in the Practice of Navigation, I have made the Experiment following, that so the quantity of a Degree, and of the whole Compass of the Earth, might at least-wise be nearly known in our English Measures.

## C H A P. II.

*An Experiment made for finding the quantity of a Degree, and so the Circumferences of the Earth and Sea in our known Measures.*

**H**AVING occasion to be in the City of *York* about the beginning of *June*, Anno 1635, I made there several Observations of the Meridian Altitude of the Sun, the last of which was made the 11th of *June*; the Sky was every of those days something overcast at Noon, yet not so much but that an Observation might be made to a near scantling: And because the last of those Observations is most fit for the present occasion, and that day was as clear as any of the other, we will here especially make use of that, being as followeth.

*Upon*



## The Seaman's Practice.

Upon the 11th of *June*, 1635, I made an Observation near the middle of the City of *York*, of the Meridian Altitude of the Sun, by an Arch of a *Sextant* of more than 5 Foot Semidiameter, and found the apparent Altitude of the Sun that Day at Noon to be 59 deg. 33 min.

I had also formerly upon the 11th of *June*, Anno 1633, observed in the City of *London*, near the Tower, the apparent Meridian Altitude of the Sun, and found the same be 62 deg. 1 min.

And seeing the Sun's Declination upon the 11th day of *June*, 1635, and upon the 6th day of *June*, 1633, was one and the same, without any sensible difference; and because these Altitudes differ but little, we shall not need to make any alteration or allowance, in respect of Declination, Refraction, or Parallax: Wherefore subtracting the lesser apparent Altitude, namely 59 deg. 33 min. from the greater 62 deg. 1 min. there remains 2 deg. 28 min. which is the difference of Latitude of these two Cities, namely, of *London* and *York*.

Also by the aforesaid Observation made in *York*, it appears that the Latitude of that City is 53 deg. 58 min. almost.

But to our purpose: Coming at that time from then to *London*, I further found by measure, that the Parallel of *York* is from the Parallel of *London* 9149 Chains; every Chain being 6 Poles, and every Pole 16½ of our English Feet; that is, every Chain 99 Feet. (After what manner I found this to be so, we shall further express hereafter:) But thus, as I say, I found that *York* is more northerly than *London* by 9149 Chains: And before we have noted that these two places differ in Latitude 2 deg. 28 min. therefore it follows, that 2 deg. 28 min. of the Meridian of the Earth and Sea, is equal to 9149 Chains. And if accordingly we would know how many of these Chains are contained in 1 deg. we may find that by the Rule of Proportion, first reducing the degrees into Minutes; and then say,

If the difference of Latitude	148 00. ar.	7.82974
give such a number of Chains,	9149	3.96137
Then 1 Degree, that is	60	1.77815
gives of such Chains	3709	3.56926

and somewhat more, namely 5 Feet, which reduced into Feet, make 367196; that is, 367200 Feet in a Degree, lacking 4 Feet, which here we regard not.

Thus then according to this Experiment it is evident, that one degree of a great Circle measured on the Earth is near 367200 Feet, which in our Poles of 16½ Feet, is 22254 Poles, and about one half; and



these reduced into Furlongs, at 40 Poles to the Furlong, make 556 Furlongs and 14 Poles: and lastly, these reduced into our English Miles, of 8 Furlongs to a Mile, make 69 Miles, and 4 Furlongs 14 Poles, that is  $69\frac{1}{2}$  Miles and 14 Poles in a Degree.

And hence, according to the most approved *Hypothesis* of the Sphericity of this Terrestrial Globe, we may find the Compass of it as followeth. But first, you may note, that we speak not here of the Compass of the Earth in any Parallel, or lesser Circle described upon any side thereof, that being various (according to the different distance of those Circles from their Poles) but of the Compass taken in the middle or greatest Thickness of the Globe; namely, in any great Circle, such as divide the whole Globe into two equal parts, of which kind are the Equinoctial and all Meridians, &c. this being properly the *Perimeter* or *Compass* of a Spherical Body.

Now seeing a Degree is the 360 part of the Circumference of a Circle (for any Circumference being divided actually, or by supposition, into 360 equal parts, those parts are called Degrees) if we can find how many Feet, Paces, Miles, or other known Measures are contained in one of those Degrees, then shall we easily conclude how many of the same known Measures are contained in the whole Circumference: But by the former experiment we find, that in one deg. of a great Circle on the Spherical Superficies of the Earth, there is contain'd 367200 Feet; therefore it is evident that 360 times 367200 Feet is the compass of the whole: wherefore multiplying 367200 by 360, the Product is 132192000 Feet, which reduced into Poles, is 8011636: and these reduced into Furlongs, are 200290 Furlongs 36 Poles: And lastly, these reduced into Miles, are 25036 English Miles, and somewhat more, for the Circuit of the Earth and Sea.

If further, we desire the Diameter and Semidiameter of the Earth. Forasmuch as it is proved by *Archimedes*, that the proportion of the Circumference of a Circle is the Diameter thereof almost, as 22 to 7: Therefore by the Rule of proportion, as 22 to 7, so is the Circumference of the Earth to the Diameter thereof: So that multiplying the Circumference of the Earth, namely 132192000 Feet by 7, and dividing the Product, namely 925344000 by 22, the Quotient, namely 42061091, is the Diameter of the Earth in Feet, the half whereof, namely 21030545 Feet, is the Semidiameter of the same, being 21 Millions of Feet, and somewhat more: these reduced into English Miles, as before we did the Circumference, shew the Diameter of the Earth to be 7966 Miles, and somewhat more, and the Semidiameter



3983. And thus we have the Circumference, Diameter, and Semi-diameter of the Earth, as also the quantity of a Degree of the same Circumference, in known measures of Feet, Furlongs, and Miles, &c. There are only two things here which may seem doubtful; namely, the Experiment it self, and the *Hypothesis* of the Sphericity of this *Terrestrial Globe*, consisting of the Earth and Sea; for these being admitted, the Measures thence deduced, as before, will necessarily follow.

Now touching the Experiment; I confess, that to have made it so exact as were requisite, and in all Points, so as I shall shew in the Chapter following, would have required much more Time and Expence than mine Ability would reach unto: Yet having made Observation at *York*, as aforesaid, I measured (for the most part) the way from thence to *London*; and where I measured not, I paced, (wherein, through Custom, I usually come very near the Truth) observing all the way as I came with a Circumferentor all the principal Angles of Position for Windings of the Way (with convenient allowance for other lesser Windings, Ascents and Descents) and these I laid not down by a Protractor after the usual manner, but framed a Table much more exact and fit for this purpose, as we shall after shew; so that I may affirm the Experiment to be near the Truth.

Touching the *Hypothesis*, that the Earth and Sea make one Spherical or round Body, it is generally agreed upon by all the principal Philosophers, Astronomers, Geographers, and Navigators, Ancient and Modern; Some Reasons demonstrative for the Confirmation thereof may be these.

First; The Eclipses, especially of the Moon, which are caused by the shadow of the body of the Earth, being interposed between the Sun and the Moon, and forasmuch as this shadow doth fall upon the Moon always, and upon every side circular, and so appears to us; it is manifest by the Opticks, that the Earth from whence it proceeds is a Spherical Body.

Secondly; likewise the Eclipses of the Sun, which are caused by the interposition of the Moon between the Sun, and those places where it appears Eclipsed; I say, it could not be determined when, and in what place such an Eclipse should appear, and where not, if the Form of the Earth were not known: but seeing the places where such Eclipses happen, and where not, may be, and are usually determined, and that upon this Ground, that the Surface of the Earth is spherical, it is thence also ratified to be a Truth.

Thirdly; The Sun, Moon, and Stars do rise and set, and are upon the



the Meridian sooner to those that are resident in the Eastern Parts, than to others more Westerly, and that in a proportion answerable to the Roundness of the Earth, as the Planets and Stars are upon our Meridian at *London* sooner by almost 4 hours, than they are to those that inhabit the *Summer Islands*, and the Confines of *Virginia* and *New-England*: And so in *East-India*, and other Eastern Regions, the Sun and Stars are sooner upon their Meridian than upon ours; which is manifest to be so, as by other reasons, so especial'y by the Eclipses of the Moon: For an Eclipse of the Moon hath not in it self any diversity of Time, being at one and the same instant without respect of places, yet because in the Eastern Parts the Day is begun, and it may be far spent before it begin in places far westerly; therefore such an Eclipse may appear to the Eastern Inhabitants toward the end of the Night, which to the Western appears in the beginning or middle of the same Night with them, and so the difference will be more or less, according to the different distance of those places in Longitude.

Fourthly; Furthermore we see, that going or sailing to the Northwards, we have the Artick Pole and Southern Stars more elevated, and the Antartick Pole and Southern Stars more depressed, the Elevation northerly increasing equally with the Depression southerly, and either of them proportional to the Distances which we go: The like happeneth in going to the southwards. Besides, the Oblique Ascensions, Descensions, Occultations, Emersions, and Amplitudes of rising and setting of the Sun and Stars in every several Latitude, agreeable to the *Hypothesis* of the Earth's Sphericity. All which could not be so, if the Earth were of any other than of a Spherical Form.

Fifthly; So if we stand upon the Sea-shore and see a Ship far off under Sail, making towards the Land, at first we see only the Top-sails or highest parts, and withal do manifestly behold the Convex Superficies of the Sea as it were raised and interposing her self between our Sight and the Hull, or lower parts of the Ship, till she approacheth nearer, and this uniformly every ways alike, and proportionably to the several Distances, which doth evidently demonstrate the Spherical Roundness thereof.

Sixthly and lastly, (to add no more) The Navigations of these later times make it apparent, those especially that have been made round about the World, as those two Voyages by our famous Country-men Sir *Francis Drake*, and Mr. *Thomas Candish*, both which severally sailing from our Coasts to the *West-Indies*, and passing the Straits of *Magellane*, continued their Course Westerly, till they came into those



Parts, which are from us to the Eastward, namely, to the *East-Indies*, and so sailed still Westward till they came to *Cape bon Esperance*, and thence returned into *England*: Having sailed about the whole Terrestrial Globe, they found nothing by their Observations or Reckonings dissonant from the uniform *Sphericity* thereof in all its parts. That they came short in the number of Days, one, or reckoned the time of their Absence less by one Day and a Night than they which remained at home, this further confirms the thing in hand.

Yet whilst we speak here of the Roundness of the Earth and Sea, we intend it not so strictly as if it were a thing turned round without any Inequality to its Superficies; But as a Bowl or Ball, though it hath some Dust or small grains of Sand cleaving thereto, may still be said to be round. So, though the Land, Hills, and Mountains be somewhat raised above the Spherical Superficies of the Sea; and if there should be also some Valleys or Bottoms more depressed; yet seeing the greatest of these Inequalities have scarce any sensible proportion of the whole, we may well affirm the whole to be round.

The Relations made of the prodigious height of some Mountains, as to be 60 or 70 Miles high, if it be understood of their perpendicular or direct height, are fabulous; the Mount *Atlas*, recorded by some of the Ancients to reach up almost to the Moon, and to be as it were a Pillar for the Heavens to rest upon, being measured geographically by *Eratosthenes*, the Perpendicular, or upright height from the top thereof to the Valleys beneath, was found not to exceed 10 *Stadiums*, which of our English Measure is little more than a Mile and a quarter, a *Stadium* not much differing from our Furlong; and the like might be shewed of others.

But if we admit the highest Mountain to rise perpendicularly above the Spherical Superficies of the Sea 2 Miles; yet seeing the Diameter or whole Thickness of the Earth is, as we have before shewed, 7966 Miles, this exorbitancy or difference of 2 Miles is of small moment; yea, if there were any Mountain 8 Miles in height upright, yet this compared with the whole Thickness of the Earth, is little more than one thousand part thereof; therefore we may conclude, that this *Terrestrial Globe*, consisting of the Earth and Sea, is Spherical. We come in the next place to shew by what way of measuring we found the Parallel of *York* to be distant from the Parallel of *London* 9149 Chains. And so how the distance of the Parallels of two places may be exactly measured.



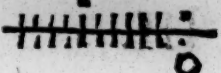
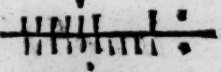
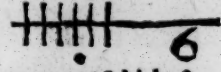
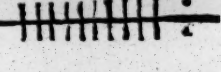
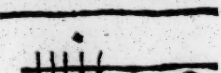


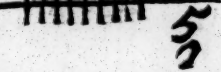
## C H A P. III.

*A most exact way for finding the quantity of the Diameter and Circumference of the Earth and Sea, and of a Degree on the same.*

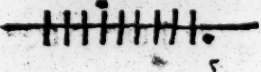
**I** Do the more fully set down the way of making this Experiment, that so I may give occasion to any who are so nobly minded for a Publick Good, as to be at that Charge to make a farther and more exact trial thereof. Now then, the best and perfectest way is, to observe so exactly as may be the Summer Solstitial Altitudes of the Sun at two places, so far distant asunder, and lying so near North and South each from other, with so direct and fair a way betwixt them as conveniently may be chosen: Suppose for Example, *Christ-Church* and *Berwick*, or some other place in the farthest parts of *Scotland*; for the farther these two places are each from other, the more perfectly may this business be performed. Then measure as truly as is possible, and set down in a Book all the way between those two places, with all the Windings, Ascents and Descents that are therein, whereby with the help of the ensuing Table, you may easily and exactly find how much the one place is more southerly than the other. For this purpose the plain Table is not the fittest Instrument, or rather a *Theodolite* or *Petaxeter*, or some other of that kind, observing diligently the Variation of the Needle. The Chain may be 6 Poles long, or rather 100 Feet, and the Table fitted accordingly (but the Table following is for Poles) if it should be much longer, it would be too heavy.

The High-ways are commonly crooked; yet because of sundry Obstacles and Impediments which are incident out of the way, and because a Man cannot certainly at first direct himself the nearest and best way to the place intended, it would be expedient to measure the distance as aforesaid; first in the High-ways leading from the one to the other, and then in the nearest and best way that could be chosen between them; and so if any notable Error happen in the one, it may be discover'd and amended in the other. The form which I observed in setting down the Measures and Angles was according to this Example.



Deg.	Distance.	North.	South.	East.	West.
S. E. 31					
S. E. 20	 				
S. E. 13					
S. E. 13					
S. W. 02					
S. E. 05	 				

It is to be understood, That the Table here following was before calculated to serve instead of a *Protractor* for a *Circumferentor*, or other graduated Instrument, and for a Chain of 3 Poles, which for the most part I use; yet it may very well be applied to a Chain of 6 Poles, (as in this business it was) reckoning every Chain to be two, &c. And thus for every ten Chains of 6 Poles to a Chain, I make two Strokes, signifying 2 Changes, or 20 Chains; and if there be any odd Chains, for those I set a Figure in another Line next below; and if moreover any odd Poles, whether one or two, for those I set another Figure in a third Line below.

Thus the last entrance before-going, being S. E. 5 Degrees,  signifies that the Line upon which I went, was from the

South-part of the Meridian to the Eastwards, making an Angle with the Meridian of 5 deg. the 9 Strokes signify 9 Changes, or 90 Chains; the Figure 5 signifieth 5 Chains, and the Figure 2 two Poles. So that it is to be read thus, South-Easterly 5 Degrees, 9 Changes, 5 Chains, and 2 Poles; and the like is to be understood of the rest. But for the most part having liberty of Ground, I end the measure of every Line, either with a whole number of Changes, or at least of Chains.

And thus proceeding all day, towards the Evening, or when else I have time convenient, I reduce all these Distances, upon what Lines or Angles soever they be, to Distances North or South, East or West, as here appeareth.



Deg.	Distance.	North.	South.	East.	West.
			2571	1545	
S. E. 31					
S. E. 20			2819	1026	
			1692	616	
S. E. 13			0169	062	
			2923	675	
S. E. 13			1754	404	
			1499		052
S. W. 02			2690	235	
			0149	013	
S. E. 05			0020	002	
Chains.	571		16286	4578	052
	2		0	52	
Poles.	1715		16286	4526	

We will explain the last, and so the rest may easily be understood; S.E. 5 deg. ~~|||||~~ 5. 2. Here because I have S. E. the numbers taken out of the Table must be put in the Columns entituled *South* and *East*. Then in the Table under 5 deg. I look for 9 Changes, and find against it 2690, and in the adjacent Column under the Complement thereof 235, and because S. E. 5 deg. is less than 45 deg. that is nearer to the South than to the East, I put into the Column, entituled *South* 2690, and in that entituled *East* 235, then again in the same Tabular Column under 5 deg. I find against 5 Chains (cutting off a Figure, because 5 Chains is but the tenth part of 5 Changes) 149 to be put in the South Column, and 13 for the East Column.

Lastly; Against 2 Poles I find for the South Column 20, and for the East 2; and the like is to be understood of all the rest.

Now supposing this last to be a place, whose Distance and Situation from the first is required; I sum up the Columns severally, and of the North and South Columns subtract the lesser from the greater, and so of the East and West Columns; and so it will appear how much North or South, and how much East or West the last place is from the first.

As in this Example, we find the first place to be to the southwards of the first 1628 Poles, for the last Figure may be cut off, being used in the Table.



Table only for the more exactness, or may be made a Fraction, and so it is  $1628\frac{6}{7}$  Poles likewise, the last place is to the Eastwards of the first  $452\frac{6}{7}$  Poles; and thus I proceed all the way.

Now touching the Angles of Ascent and Descent of Hills and Valleys; to have observed them exactly would have required more Time and Charge than I could of my self bestow, yet I made allowance for such of them as were of most moment: he that would observe them all, may either make 2 or 3 Columns more, or keep an account of them apart by themselves. But if he intend no farther use of them, but to find the nearest distance he need not set them down, but make allowance for them on the ground, keeping his distances intire without Fractions.

As, admit I observe the Ascent from a Valley to the Brow of a Hill to be 14 deg. above the Level or Horizontal Line, and that measuring, I find the distance to be 30 Poles; I turn to the Table, and under 14 deg. and against 10 Chains, I find 2911, and 726, shewing that the Level or Horizontal Distance from my station to that brow is only  $29\frac{11}{100}$  Poles, and that the height of that Brow above the level Line is  $7\frac{26}{100}$  Poles: But finding thus that the *Hypothensal* being 30, the Base or Level-Line is but  $29\frac{11}{100}$ , that is, less by  $\frac{89}{1000}$ ; becaule I would avoid this Fraction, I add to the end of the foresaid measure of 30 Poles upon a level-Line,  $\frac{89}{1000}$  of a Pole, and then I may account my self distant from the place in the Valley where I made Observation 30 Poles in a Level or Horizontal Line, and so set down the distance without a Fraction: the like is to be understood of all the other Ascents and Descents.

*Here followeth the Table.*

	1 d.	89 d.	2 d.	88 d.	3 d.	87 d.	4 d.	86 d.	5 d.	85 d.
1	300	5	300	10	300	15	299	21	299	26
2	600	10	600	21	600	31	599	42	598	52
3	900	15	900	31	899	46	598	63	896	79
4	1200	20	1200	42	1198	62	1198	84	1195	105
5	1500	26	1500	53	1497	78	1497	105	1494	131
6	1800	31	1799	64	1798	93	1796	126	1794	157
7	2100	37	2099	74	2097	110	2095	147	2093	183
8	2400	42	2398	84	2397	124	2394	168	2391	209
9	2700	47	2698	95	2696	140	2694	189	2690	235
10	3000	52	2998	105	2996	157	2993	210	2989	262
1	10	00	10	0	10	0	10	1	10	1
2	20	00	20	1	20	1	20	1	20	2



	6 d.	84 d.	7 d.	83 d.	8 d.	82 d.	9 d.	81 d.	10 d.	80 d.
1	298	31	298	37	297	42	296	47	295	52
2	597	62	596	74	594	84	592	84	590	104
3	895	94	894	111	891	125	889	130	887	156
4	1193	126	1192	146	1188	167	1185	182	1182	208
5	1492	157	1489	183	1485	209	1481	224	1477	260
6	1790	188	1787	220	1782	251	1777	281	1772	312
7	2089	220	2085	257	2080	292	2074	328	2069	365
8	2386	251	2383	292	2377	334	2371	375	2364	417
9	2686	283	2680	329	2674	376	2667	422	2659	469
10	2984	314	2978	366	2971	418	2963	460	2954	521
1	10	1	10	1	10	1	10	1	10	1
2	20	2	20	2	20	3	20	3	20	3

	11 d.	79 d.	12 d.	78 d.	13 d.	77 d.	14 d.	76 d.	15 d.	75 d.
1	295	57	293	62	292	67	291	73	290	78
2	590	114	586	124	584	134	582	146	580	156
3	883	172	881	188	876	203	873	219	870	233
4	1178	229	1174	250	1169	270	1164	290	1160	310
5	1473	286	1467	312	1463	337	1455	363	1449	388
6	1768	343	1760	374	1754	404	1746	436	1739	466
7	2060	401	2055	436	2047	472	2038	508	2030	543
8	2355	458	2348	500	2339	540	2329	580	2320	621
9	2650	515	2641	562	2631	608	2620	653	2610	699
10	2945	573	2934	624	2923	675	2911	726	2898	776
1	10	1	10	1	10	1	10	1	10	1
2	19	4	19	4	19	4	19	4	19	5



	16 d.	17 d.	18 d.	19 d.	20 d.	70 d.
1	288	83	287	88	285	93
2	576	166	574	177	570	186
3	865	250	861	264	855	279
4	1153	332	1148	352	1140	371
5	1442	413	1434	438	1426	463
6	1730	496	1721	526	1711	556
7	2019	580	2008	615	1997	649
8	2307	663	2296	703	2282	743
9	2596	746	2583	791	2567	836
10	2884	827	2869	877	2853	927
1	10	3	10	3	10	3
2	20	5	19	6	19	6

	21 d.	22 d.	23 d.	24 d.	25 d.	65 d.
1	280	107	278	112	276	117
2	560	215	556	224	552	234
3	840	322	834	337	828	351
4	1120	429	1112	449	1104	468
5	1400	537	1391	562	1380	586
6	1680	645	1669	674	1656	703
7	1960	752	1947	786	1932	820
8	2240	860	2225	899	2209	937
9	2520	968	2504	1011	2485	1054
10	2800	1075	2782	1124	2761	1172
1	9	4	9	4	9	4
2	18	7	18	8	18	8



	26 d.	64 d.	27 d.	63 d.	28 d.	62 d.	29 d.	61 d.	30 d.	60 d.
1	270	131	267	136	265	141	262	145	260	150
2	540	263	534	272	530	282	524	290	520	300
3	810	394	801	408	795	423	786	435	780	450
4	1079	525	1068	544	1060	564	1048	581	1040	600
5	1348	657	1336	681	1324	704	1312	727	1299	750
6	1618	788	1603	817	1589	845	1574	872	1555	900
7	1888	919	1870	953	1855	986	1836	1017	1819	1050
8	2157	1050	2138	1089	2120	1127	2098	1162	2079	1200
9	2427	1182	2405	1225	2384	1267	2361	1308	2339	1350
10	2696	1315	2673	1362	2646	1408	2624	1454	2598	1500
1	9	4	9	5	9	5	9	5	9	5
2	18	8	18	10	18	10	18	10	18	10

	31 d.	59 d.	32 d.	58 d.	33 d.	57 d.	34 d.	56 d.	35 d.	55 d.
1	257	154	254	159	252	163	249	168	246	172
2	514	309	508	318	504	326	498	336	492	344
3	773	463	763	477	755	489	747	504	738	516
4	1028	617	1017	636	1007	653	995	671	983	688
5	1285	772	1272	795	1258	817	1243	838	1228	860
6	1542	927	1526	954	1510	980	1492	1006	1474	1032
7	1809	1081	1780	1113	1762	1144	1741	1174	1720	1204
8	2057	1235	2034	1272	2013	1307	1990	1342	1966	1377
9	2314	1390	2288	1431	2265	1470	2238	1510	2212	1549
10	2571	1545	2544	1590	2516	1634	2487	1677	2457	1711
1	9	5	8	5	8	5	8	6	8	6
2	18	10	16	10	16	10	16	12	16	12



	36 d.	37 d.	38 d.	39 d.	40 d.	41 d.	42 d.	43 d.	44 d.	45 d.
1	243	176	240	180	236	185	233	189	230	193
2	486	352	480	360	472	370	466	378	460	386
3	729	528	720	540	709	555	699	567	690	578
4	972	705	960	720	945	739	932	756	920	771
5	1215	881	1198	902	1182	923	1185	944	1149	964
6	1456	1057	1438	1082	1418	1108	1398	1133	1379	1157
7	1699	1234	1678	1262	1654	1293	1631	1322	1609	1350
8	1942	1410	1918	1443	1890	1479	1865	1511	1839	1543
9	2185	1586	2157	1624	2126	1663	2094	1700	2069	1735
10	2427	1763	2395	1805	2369	1847	2331	1888	2295	1928
11	2670	1939	2646	1978	2628	2025	2509	2066	2475	2099
12	2913	2116	2880	2160	2892	2202	2684	2244	2706	2322

	41 d.	42 d.	43 d.	44 d.	45 d.	46 d.	47 d.	48 d.	49 d.	50 d.
1	226	197	223	201	219	205	216	208	212	212
2	452	394	446	402	438	410	432	416	424	424
3	678	591	669	603	658	614	648	625	636	636
4	904	788	892	803	878	819	864	833	849	849
5	1130	986	1114	1003	1097	1023	1079	1042	1061	1061
6	1356	1181	1337	1204	1316	1228	1295	1250	1273	1273
7	1582	1378	1560	1406	1533	1433	1511	1458	1485	1485
8	1808	1575	1783	1607	1754	1638	1727	1666	1697	1697
9	2034	1772	2006	1807	1974	1842	1943	1874	1910	1910
10	2260	1968	2229	2007	2194	2046	2158	2084	2122	2122
11	2486	2165	2446	2204	2391	2238	2350	2276	2314	2314
12	2712	2362	2682	2402	2589	2436	2548	2474	2512	2512



The Structure of the Table is from this Ground :

As Radius is in proportion to the Distance of two places measured in their Rhomb ; so is the Sine of the Complement of that Rhomb, to the difference of the Latitude of the two places.

And so is the Sine of the Rhomb, to the distance of the Meridians of those two places. As, admit I measure South-Easterly 20 deg. 31 Poles, here then the Rhomb upon which I measure, making with the Meridian an Angle of 20 deg. I say,

As Radius is in proportion

to the Distance measured, 300 Poles ; ————— 2.47712

So is the Sine Complement the Rhomb, S. E. 20 deg. ————— 9.97299

to the Difference of Latitude 281  $\frac{1}{2}$   $\frac{9}{10}$  fere, ————— 2.45011

Whereby it appears, that the Distance of the Parallels of these two places is 281  $\frac{1}{2}$   $\frac{9}{10}$  Poles ; or that the place whereto I measure, is more southerly than the place from which I measured by 281  $\frac{1}{2}$   $\frac{9}{10}$  Poles. Now for the distance of their Meridians say,

As Radius is in Proportion

to the Distance measured, 300 Poles, ————— 2.47712

So is the Sine of the Rhomb S. E. 20 deg. ————— 9.53405

to their Distance in Longitude 102  $\frac{6}{10}$   $\frac{6}{10}$  ————— 2.01117

And thus I find the place whereto I measured, is more Easterly than the place from which I measured, by 102  $\frac{6}{10}$   $\frac{6}{10}$  Poles, and somewhat more. And in like sort may be found all the other numbers expressed in this Table ; but having thus found for every deg. to 45 deg. two Numbers, the rest may be deduced from them, as in this Example : 300 Poles at three Poles to the Chain, is 100 Chains, or ten Changes ; finding that in ten Changes upon this deg. the difference southerly is 281  $\frac{1}{2}$   $\frac{9}{10}$  Poles, it must be for five Changes, which is just half so much by almost 141 ; and for one Change, which is a tenth part, 28  $\frac{1}{2}$   $\frac{9}{10}$  fere, and so for two Changes twice so much, that is 56  $\frac{1}{2}$   $\frac{9}{10}$  ; for three Changes thrice so much, that is, the sum of the two former, namely, 84  $\frac{1}{2}$   $\frac{9}{10}$ , and so by Addition only you may find the rest, as in this Table, which I shall need to prosecute no further. And thus you may make it to the hundredth or thousand parts of a Pole ; but this for ordinary occasions, for which it was at first intended, may suffice. And according

Ch	Poles.
1	28.19
2	56.38
3	84.57
4	112.76
5	140.95
6	169.14
7	197.33
8	225.52
9	253.71
10	281.92



according to this Example, it will be easie to frame the like Table for a Chain of any other size, or for any other Measure which you use.

It may be objected, That howsoever this Rule holds true in Plain Triangles, yet the Triangles here used are neither Plain nor Spherical; for a Plain Triangle is made of three right Lines, a Spherical of three Arches of great Circles: But in this the three sides are of several kinds; namely, one side is an Arch of the Meridian, and so of a great Circle; another an Arch of a Parallel, and so of a lesser Circle; the third side, or *Hypothensal*, being the Rhomb, is no Arch of a Circle, but a Segment of an *Helispherical* Line.

But I answer, That notwithstanding this may be speculatively conceived, and so demonstrated to be no Plain Triangle; yet in so small Distances as these which here we use, there can be no sensible, nor scarce any numerable Difference. Yea, the distance between two Parallels by the Rhomb and Distance given (being the thing here chiefly aimed at) is very exactly found by this Rule, as before we have shewed, and as is more fully demonstrated by Mr. *Wright*, in the twelfth Chapter of his Book, *Of the Correction of Errors in Navigation*: Whence we may conclude, that the parts of the Meridian collected by this Table according to the Rhombs and Distances, as we have before shewed, do give the true measure of the Segment of that Meridian intercepted between the Parallels of the two places proposed.

#### C H A P. IV.

*Of the Difference of Longitude, Position, and Distance of York and London: And how the Maps of England may by this Experiment be reformed, especially in the Latitude of Places.*

**W**E come next to speak of the Easterly and Westerly Distances, gathered as before is shewed by these Tables, and to find thereby the Difference of Longitude; and of this we will give an Example in the foresaid Experiment; whereby we find that the Distance in Longitude, or the East and West Distance between *York* and *London*, is near 14000 Poles, *London* being so much more Easterly than *York*. And before we have found that in a degree of the Meridian, and consequently in a degree of the Equinoctial, there is near



3709  $\frac{1}{2}$  Chains, at 6 Poles to the Chain, and this 14000 Poles converted into such Chains, is 2333  $\frac{1}{2}$ .

Which 2333  $\frac{1}{2}$  Chains, for finding the Difference of Longitude, are not to be reckoned in the Parallel of *Tork*, that being too much Northerly; neither in the Parallel of *London*, being too much Southerly, but in a middle Parallel between both; namely, about the Latitude of 52 deg. 45 min. Now to find what difference of Longitude is answerable to this 2333  $\frac{1}{2}$  Chains in the Parallel of 52 deg. 45 min. say,

As *Radius* is in proportion

to Sine Compl. the Latitude sc. 52 deg. 45 min. 9.78197

So is the measure of a degree in the Equinoctial 3709  $\frac{1}{2}$  3.56927

to the measure of a degree in that Parallel 2245  $\frac{1}{2}$  3.35124

And thus we find that in the Parallel, whose Latitude is 52 deg. 45 min. there are 2245  $\frac{1}{2}$  Chains answering to a degree, whereby it appears that the difference of Longitude between *Tork* and *London*, is more than one deg. And to find how much more, say again by the Rule of Proportion;

As the measure of a degree 2245  $\frac{1}{2}$  Co. Ar. ——— 6.64876

is to a degree in seconds, 3600 ——— 3.55630

So is the measure given, 2333  $\frac{1}{2}$  ——— 3.36797

to the number of seconds, 3741 ——— 3.57303

Which reduced, is 1 deg. 2 min. 21 sec. And thus we find that *London* doth differ in Longitude from *Tork* 1 deg. 2 min. 21 sec. being so much more Easterly.

Thus having the difference of Latitude, as also the difference of Longitude between these two places, we may (according to the second Problem of sailing by *Mercator's* Chart) find the Rhomb from *London* to *Tork* to be 14 deg. 20 min. from the North to the Westward; that is, North and by West 3 deg. 5 min. Westerly, and the distance in that Rhomb 9442 Chains. But their distance in the High-way, by reason of the crookedness and unevenness of it, was more by about an eighth part.

And the like might be done for other immediate Places between these, but affecting brevity, we pass that over, as not much pertinent to our present purpose; only expressing the Latitudes of some of the principal of them, as followeth.



		<i>Latitudes.</i>	
		deg.	min.
As the Latitude of <i>York</i> , we find to be	_____	53	58
<i>Doncaster</i> , _____	_____	53	32
<i>Newark upon Trent</i> , _____	_____	53	5
<i>Grantham</i> , _____	_____	52	54
<i>Stamford</i> , _____	_____	52	38
<i>Huntington</i> , _____	_____	52	19
<i>Royston</i> , _____	_____	52	3
<i>Ware</i> , _____	_____	51	48
<i>London</i> , _____	_____	51	30

We further noted in this Experiment, that howsoever the number of Miles between *Ware* and *London*, are almost the same by estimation that they are by measure; yet all the way besides from *York* to *Ware*, a measured Mile consisting of 320 Poles, is but three quarters of a Mile, as the Miles lie by estimation or common account; so that every where (for the most part) three Miles by estimation make four measured Miles; and a min. or the 60th part of a deg. is almost in the middle between them both. So that look how much a measured Mile is less than a min. so much, or somewhat more is a Mile by estimation greater than a min. for as there is contained in a degree of measured Miles  $69\frac{1}{2}$  and somewhat more, as we have before shewed; so of our common estimated Miles, there are contained about  $51\frac{1}{2}$  in a degree.

Upon these grounds the whole Map of this Kingdom might be much rectified, especially in the Latitude of Places; for tho we cannot hence determine certainly the Latitudes of any other places besides those which were in the way, or at least in sight as we came up (the principal of which we have before noted.) Yet we may nearly conjecture the Latitudes of most Parts of *England*, by their Distances and Positions from these; but these things being besides our scope and purpose in this place, we shall only compare the Latitude of some principal places, probably gathered from this Experiment, with the Latitudes of the same places, as they are set down by Mr. Speed in his Geographical Description of *England*, that such as please to examine both in any Particulars, may know to which they may more safely lean.



	Latitud. by this Exper.	Lat. by Mr. Sp. Map.		Latitud. by his Exper.	Lat. by Mr. Sp. Map.
	D. M.	D. M.		D. M.	D. M.
Canterbury	51 17	51 29	Northampton	52 14	52 36
Chicester	50 48	50 51	Huntington	52 19	52 44
Guilford	51 12	51 22	Stamford	52 38	53 04
Winchester	51 03	51 11	Leicester	52 40	53 06
Dorchester	50 40	50 44	Lincoln	53 14	53 50
Excester	50 43	50 48	Newark up- on Trent.	53 05	53 38
Wells	51 12	51 22	Nottingham	53 00	53 32
Salisbury	51 04	51 12	Derby	52 58	53 30
Reading	51 28	51 42	Stafford	52 52	53 22
London	51 30	51 45	Shrewsbury	52 47	53 16
Colchester	51 58	52 16	Chester	53 16	53 52
Ipswich	52 08	52 30	Lancaster	54 10	54 57
Norwich	52 42	53 10	York	53 58	54 44
Cambridge	52 12	52 32	Richmond in Yorkshire	54 28	55 18
Hertford	51 49	52 06	Kinston up- on Hull	53 48	54 29
Bedford	52 08	52 30	Doncaster	53 32	54 12
Buckinham	52 00	52 20	Durham	54 50	55 45
Royston	52 04	52 24	Carlile	55 00	55 56
Oxford	51 46	52 02	Newcastle	55 03	56 01
Glocester	51 53	52 12	Berwick	55 54	57 03
Hereford	52 07	52 27			
Worcester	52 14	52 26			
Warwick	52 20	52 45			

The Latitude of these places in the first Column expressed are such as are probably gathered from this Experiment. But in the second Column there is set down the Latitudes of the same places, as they are expressed by Mr. John Speed in his Map of England, set forth in his Book, entituled, *The Theatre of the Empire of Great Britain*; and lest there should be any mistake in his Map, I have conferred these Latitudes thence gathered, with the Latitudes of the same places, set down by him in words at large, in his Descriptions of each several County, and find them nearly to agree, except in the Latitude of *Berwick*, which



in his Map he makes to be 57 deg. 3 min. But in his Historical Description of *Northumberland*, he relates it to be 55 deg. 48 min. which last is much nearer the Truth, but seems not to be his meaning; because then he should make it more Southerly than *Newcastle*; yea, more Southerly than he doth *Carlisle*, which by his Map, and also by his words in his Relation of *Cumberland*, is in the Latitude of 55 deg. 56 min. whereas *Berwick* is above 50 Miles more Northerly.

By these you may nearly conjecture the Latitudes of other parts of *England*, lying in or near the same Parallel with any of them: And hence it also appears, that the difference of Latitude between *Berwick*, and the South Coast of *England* near *Christ-Church*, is little more than 5 deg. not 6 deg. and more, as some of our Maps make it. But these things we must leave, that we may proceed to that which is principally intended, only we will first touch a little upon the use of the foregoing Table, in plotting and surveying of Land.

## CHAP. V.

*To delineate the Plot of any Forest, Park, Common, or other piece of Ground; as also of Rivers, Harbours, &c. speedily and most exactly.*

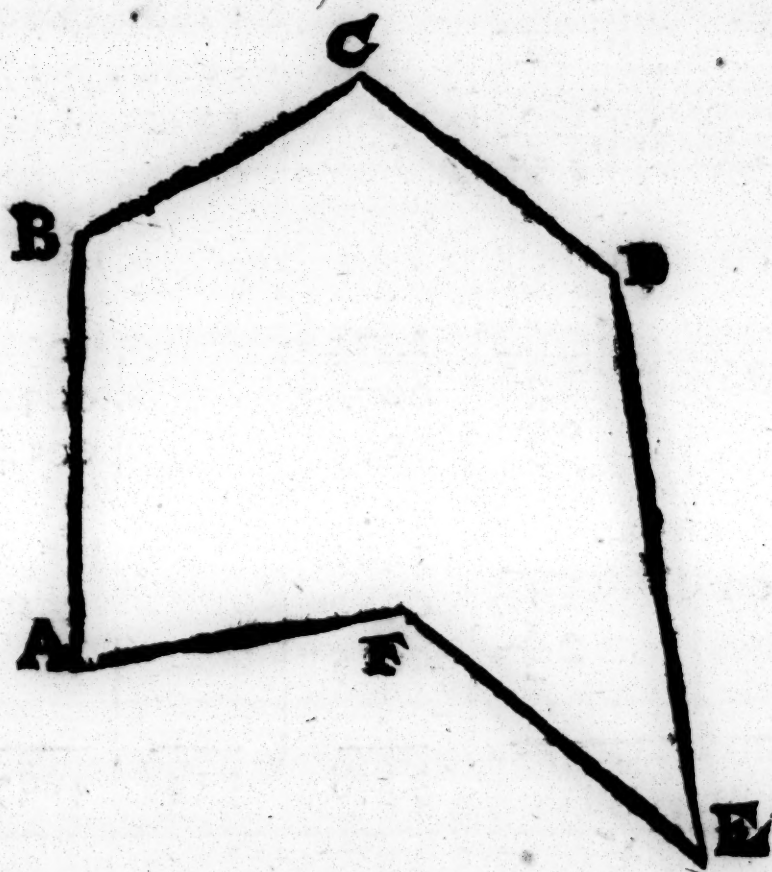
**M**Y intent is not here to prosecute at large the Plotting of Grounds, being a thing handled by others, treating of *Surveying*: But considering the ways by them directed, and by others practised, in delineating or laying down the Distances and Angles observed by the *Circumferentor*, *Theodolite*, *Peraſtor*, or other graduated Instrument, is by a *Protractor*, and that the Table before-going, or that which followeth towards the end of this Treatise, serveth for that and the like purposes, almost as speedily, and far more exactly; I shall crave leave to digress a little to shew the Use of it as briefly as I may. Therefore passing over the method to be used in setting down the Names of the Grounds, the Tenants, Borders, and other remarkable things, leaving every Man in these to the ways whereunto he is accustomed; You may (as sometimes I do) make a Book in a long *Octavo*, and upon the left side thereof set down such things as these before mentioned, reserving every right side, and dividing them by ruled Lines into six Columns, as hereafter following appeareth.

And



And having taken and set down your Notes in the Field on the left sides or Pages of your Book, you may in the Evening, or next Morning before you go out, or when else your occasions will permit, set down in the first Columns on the right side, how many degrees the Lines upon which you have traversed, are distant from the North or South part of the Meridian towards the East or West; and in the second Columns the quantity of the same Lines, in Changes, Chains, and single Poles, and parts of Poles.

As in this Figure; suppose the Line from A to B to be directly East, 7 Changes, that is, 7 times 30 Poles, or 210 Poles. From B to



C to the Eastwards of the South 35 deg. 5 Changes, and 1 Chain: from C to D to the Eastwards of the South 32 deg. 5 Changes, and 4 Chains; from D to E to the Westwards of the South 80 deg. 10 Changes; from E to F to the Eastwards of the North 35 deg. 6 Changes, 3 Chains, and two thirds of a Pole; and lastly, from F to A, the place where I first began, to the Westwards of the North, 9 deg. 5 Changes, 3 Chains,  $2\frac{1}{2}$  Poles. All these I express in the first and second Columns on the right side, as hereafter following appeareth.

Which done, I take the Table, and find there the Northing and Southing, Easting or Westing answering to these Degrees and Distances, and set them down accordingly. As for the first, bring East 7 Changes, I set down in the East Column 210 Poles with a Cipher







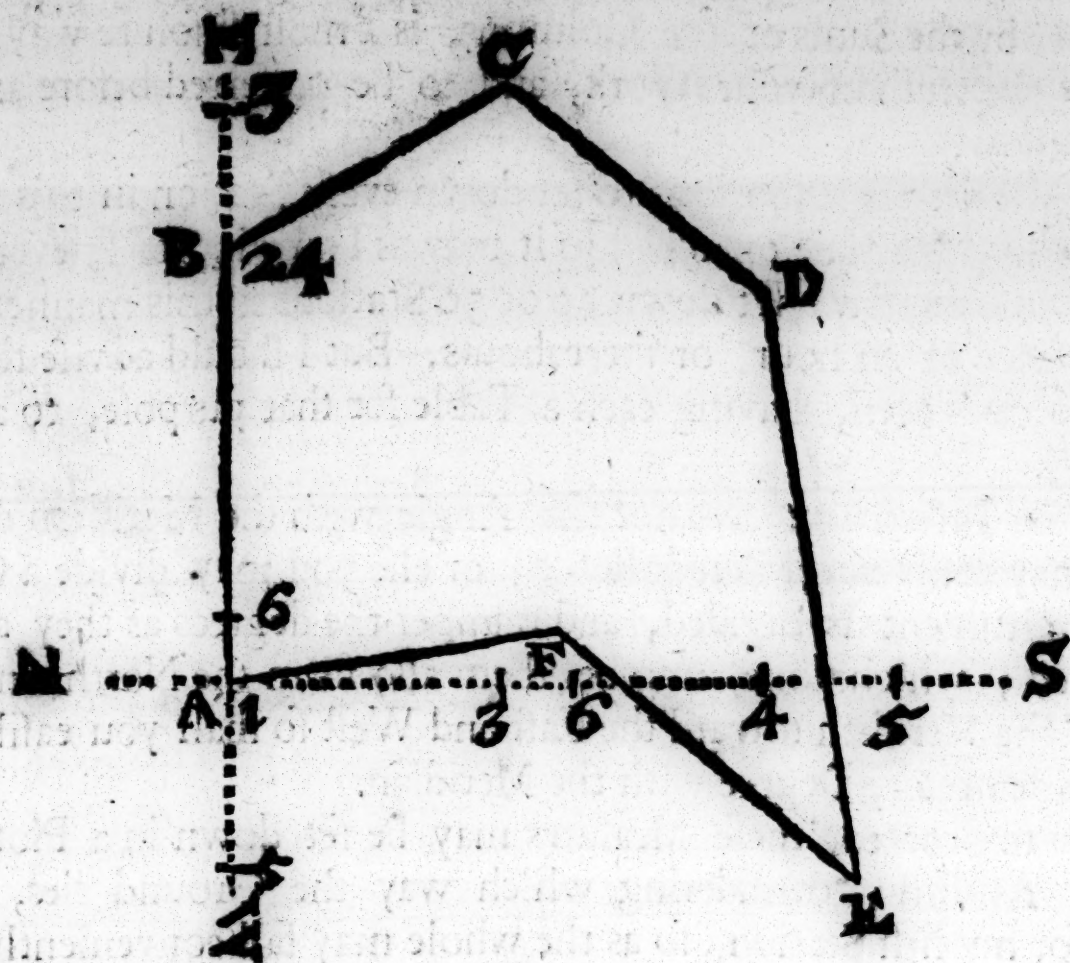
cause here are six Angles) the Product is also eight right Angles. But the other by the Sums of the Columns, is a most absolute way for examining the truth of your Work, and to be preferred before any other that I know.

It may seem very laborious to set down every Station in this manner, but one that is a little exercised in it, may, as I take it, (for I never observed the time exactly) set down 40 or 50 Stations in this manner, within the space of an hour, or thereabouts. But I should advise that it be done by two Men, having each a Table for that purpose, to avoid all mistakes.

If your Instrument give not the Angle with the Meridian expressly, yet it may easily be gathered thence; or else you may divide a Circle as your Instrument is divided, and number the degrees as they are there numbred; which done, number them also from the North and South part of the Meridian toward the East and West so shall you easily know the Angle of any Degree with the Meridian.

Now to proceed, these Measures may be set down in a Plot several ways. As first; considering which way the Ground lies, I take a Point for my first Station, so as the whole may fall conveniently within the Plot, which let be the Point A, by which Point I draw a Meridian and Parallel, namely two right Lines intersecting one another at right Angles; whereof let N. S. be the Meridian running North and South, and E. W. the Parallel running East and West; this done, I look to the North and South Columns, and there, first in the South Column, and against the third Station, I find 1253, that is, 125.3 Poles, this I set in the Meridian from A to the Southwards, and mark the Point with the Figure 3; then in the South Column against the fourth Station, I find 1374, which I set in the Meridian from 3 to 4; also against the first Station I find 521, which I set the Meridian from 4 to 5. Then against the sixth Station, I find in the North Column 1553, which I set in the Meridian from 5 to 6; also against the seventh Station, which is the same with the first, I find 1595, which I set in the Meridian from 6, and it falls upon A, which is the first Station. And thus have I done with the South and North Columns.





In like sort I express the Measures in the East and West Columns in the Parallel E. W. As finding first in the East Column 2100, I set it down from A to the Eastwards, and it extends to B, where I set 2, signifying my second Station; I find next in the East Column 877, which I set down in that Parallel from 2 to 3, next in the West Column 859, which I set in that Parallel from 3 to 4, and so I proceed with the rest. And having thus set down the Measures in the Meridian and Parallel, we have also as it falls out in this Example, two Stations express'd, namely, A and B; now for the third, I take in the Parallel with my Compasses the distance A 3, and setting one Foot in the Meridian at 3, I strike an Arch near C; also taken in the Meridian the distance A 3, and fixing one Foot in the Parallel at 3, I cross the foresaid Arch near C, the intersection of these two Arches in the Point C, representing the third Station.

In like sort I proceed to find the Points D E F, for the fourth, fifth and sixth Stations; then drawing Lines, namely from the first Station A to the second B, and from the second to the third C, &c. we shall describe the Figure required, A B C D E F.

Otherwise, whereas here you add and subtract the several Distances of South and North, as also of East and West by your Compasses, you may



may with a little more pains add and subtract them by the Pen, which is the better way.

As having set down in the Meridian the Southerly Distance of the third Station 1253, I add thereto 1374, which is against the fourth Station, the Sum is 2627, the Southerly Distance of the fourth Station, which I set in the Meridian from A to 4. Again, to this I add 521, so have I 3148, the Southerly Distance of the fifth Station A 5, from which subtracting 1553, the Northerly Distance set against the sixth Station, there remains 1595, which is the Southerly Distance of the sixth Station, to be set in the Meridian from A to 6. Lastly, from this, abating the Northerly Distance of the first Station from the Sixth, which I find there also to be 1595, there remains 0. Shewing that I am returned to the same Parallel, or East and West Line, in which at first I began. And in like sort, you may proceed with the East and West Columns, and then by the intersection of two Arches, find every Station as before.

Other ways might be prescribed, which will not be hard to find of your self. And as we may thus lay down any irregular right-lined Figure far more exactly than by the *Protractor*: So when it is laid down after this manner, we may cast up the *Area* or superficial quantity of it, very exquisitely: Yea, if there should be a Plot drawn (according to the Angles and Distances here given) after the usual manner, by a Scale so large, that the Plot should be an hundred times so great as this; yet could not the Content thereof be cast up so exactly and certainly as it may be here.

But I must not insist upon these things, they may of themselves be conceived, and my intent is only to touch them, that I be not prevented of time, and by other occasions, from handling those things which I have here more especially intended.

But as I have said, this course is chiefly to be used in Plotting large Grounds, and there indeed are graduated Instruments, especially to be used for other smaller Grounds, there is none more fit than the *Plain Table*.



## C H A P. VI.

*Of the Compass of the Earth, and the quantity of a Degree, according to the most approved Experiments Ancient and Modern.*

**A**Lthough the Compass of the Earth hath been in some sort observed by divers of the Ancients: yet for some of them we cannot certainly gather what Measures they used; others used no Measure at all, but assumed the Distance of Places to be such as it was estimated by Travellers to be, and likewise the Latitude; therefore it will be needless to insist upon the Examination of their Observations: others of them which were taken by measure, and which we may upon any good ground reduce to our Measures, are these which follow:

*Willebrordus Snellius* in his Book entituled *Eratosthenes Batavi*, cites *Abel Fedas*, a most diligent *Arabian* Geographer, that lived about the Year of Christ 1322, who records, that about the Year of Christ 827, certain Men, skilful in the Mathematicks, did, by the Commandment of their Prince *Almanon*, measure in the Fields of *Mesopotamia* (as he gathers) under one and the same Meridian, from the North towards the South, the quantity of a Degree, and found it to be 56 Miles, or somewhat more. The quantity of their Mile, according to *Alphragannus*, was 4000 Cubits, or 6000 Feet, whence the quantity of a Degree should be 336000 Feet: but of the length of their Foot we are something uncertain; only they define it to be so long as the extent of 96 Barley Corns laid side by side; whereas the *Rhynland* Foot, according to Tryal by him made, is but the extent of 90 Corns laid in like manner; so that if there be no inequality in the Grains, then 90 *Arabian* Feet are equal to 96 *Rhynland* Feet. But 96 *Rhynland* Feet are found to be about  $91\frac{1}{2}$  *English* Feet; therefore also by the Rule of Proportion, 336000 *Arabian* Feet do make of our *English* Feet 370222. So that according to this Experiment of the *Arabians*, a Degree should contain 370222 of our *English* Feet. And before we have found by the Observations taken at *London* and *York*, and by the distance of their Parallels measured, that a Degree contains of our

*Almanon or al-Mamon Hegyia English*  
*Christ. era. 813* — *198*



*English Feet* 367200. The difference is only 3022 Feet, that is, about the  $\frac{1}{20}$  part of a Degree, or half a Minute.

He cites next *Alhazen* the *Arabian*, who in his Book *de Crepusculis*, declares the Compass of the Earth to be 24000000 Paces; so that proportionally there must be in one Degree 66756  $\frac{2}{3}$  Paces, that is 333333 *Arabian Feet*. And seeing that 90 *Arabian Feet* make of our *English Feet* 99  $\frac{1}{2}$ ; therefore by the Rule of Proportion 333333 *Arabian Feet*, make of our *English Feet* 367283. So that according to *Alhazen*, there should be in a Degree 367283 of our *English Feet*, differing from the Experiment which I made only 83 Feet in a Degree.

I have not strained these numbers to bring them to this nearness, they are the same in effect which are set down by *Snellius* in his *Eratosthenes Batavus*, who with great Industry and Judgment hath compared the Measures of the Ancients, and the Measures used by several Nations in these times, with the *Rhynland Foot*. Much less have I strained my own Numbers to draw them up to these: But on the contrary, I confess upon the sight of his Book, observing the great Pains and Industry which he professeth himself to have bestowed, and which I doubt not but he did imploy in making his Experiment, and how he had found the measure of a degree to be much less than mine, as we shall after shew; I began to doubt that I had not made sufficient allowance for the unevenness of the ways, and for some small bendings, sometimes to the right-hand, sometimes to the left, the Observation whereof I wittingly neglected, to spare time and expence. For I did often observe a Mile or two before me, some Mark in the High-way, noting the degree and measuring to it in the Way, neglecting to observe the intermediate swervings of the Way, sometimes three or four degrees towards the Right-hand, sometimes as much to the Left; but making such allowance for that, and for the unevenness as I judged sufficient. And some Men may think, that the exact Observation of these lesser things thus neglected, and regulated only by Judgment or Conjecture, might deceive me much: But they may consider, That if there be two places a Mile distant, that is, in a right Line 320 Poles, if you measure from one of these places towards the other, not in that right Line, but always swerving from it by an Angle of four degrees, sometimes to the Right-hand, sometimes to the Left, till you come to that other place; I say, that notwithstanding all these swervings (if there be nothing else to augment the measure) it will not amount to 321. Now considering that I had all the Way, as occasion required, made such allowance as seemed convenient, and so found 367200 Feet in a degree,



before I compared it with the Measures taken by any other; I resolved not to diminish nor to augment the Numbers thus arising by my Observations, Measures, and Allowances, in respect of the Opinions, Observations, or Measures of any other Man, until there be made some Experiment more evident and exact than any yet extant. And I am something the more confirmed by the near agreement of these two Testimonies before recited, both exceeding me a little in the measure of a degree. But we cannot confidently rest upon them, because of that inequality which may be of Corns or Grains; for theirs may haply be something greater or lesser than ours.

Both these measures of a Degree do much exceed the quantity of a Degree found by *Snellius*, but when he compares them with his own another way, namely, placing the Barley-Corns so that they may not lie flat, but be set up edgewise, and so by 96 Corns to make a Foot, and by such Feet to measure a Degree; then he finds that the quantity of a Degree, according to the *Arabians*, is much less than by his Experiment it should be: but if some be laid flat, and others set up edgewise, the *Arabian* Measure of a Degree will agree with his. And so he proposeth this doubt, Whether the 96 Grains, whereof the *Arabian* Foot doth consist, must lie flat or be set up edgewise, or some of them to lie flat, and others to be set up edgewise. But it is most probable that they must lie flat, that being the position which they are apt unto by nature; they cannot be set edgewise without much trouble, especially so many together as make the length of a Foot; and so the *Arabian* Measure of a Degree doth near agree to this of mine.

We come next to hear the determination of *Ptolemy* of *Alexandria*, whose Authority and Credit in the solution of this Question, is not inferiour to any of the Ancients. He affirms the Compass of the Earth to be 180000 *Stadiums*, and the quantity of a Degree 500 *Stadiums*; the same (as *Strabo* saith in his second Book of Geography) was before affirmed by *Posidonius*. Also *Murinus Tyrinus* (before *Ptolemy*) had determined the quantity of a Degree to be 500 *Stadiums*. *Ptolemy* confirms it, not simply from their Relations, but as it seems from his own Experience, and that by some Measures diligently taken: for in the eleventh Chapter of the first Book of his *Geography* he hath these words; *Sed in hoc quoque rectè sentit, partem unam, qualium est Circulus maximus tricentorum sexaginta, quinginta in Terra constitutere Stadia, id enim confessis dimensionibus consonum existit.* Also lib. 7. cap. 5. *Ita ut pars una, seu gradus unus quinginta contineat Stadia, quem admodum ex diligentibus deprehensum est dimensionibus.* Now a *Stadium*



not only amongst the *Greeks*, but, as appears by *Herodotus*, amongst all other Nations of *Asia*, and in *Egypt*, did consist of 600 Feet; therefore a Degree according to *Ptolomy*, must contain 300000 Feet. But the Egyptian or Alexandrian Foot was much greater than our Foot; for, as we have before said, the ancient Roman Foot was greater than ours, and the Egyptian Foot was much greater than the Roman: For it is often testified by *Hero Mechanicus*, that five Alexandrian Feet make six Roman Feet. And Mr. *Snellius* hath very ingeniously gathered both from *Philander*, and other-ways, that the Rhymland Foot is equal to the ancient Roman Foot; therefore also five Alexandrian Feet are equal to six Rhymland Feet: So that by the Rule of Proportion, 300000 Alexandrian Feet, will make of Rhymland Feet 360000. But by the size of our English Foot, which was sent him from the Iron Standard in *Guild-Hall*, he finds it to contain but 968 such parts as the Rhymland contains 1000: So that 968 Rhymland Feet are equal to 1000 English Feet, or 121 Rhymland Feet are equal to 125 English Feet. Therefore also by the Rule of Proportion, 360000 Rhymland Feet are equal to 371900 of our English Feet. Therefore according to *Ptolomy*, there are contained in a Degree 371900 of our English Feet. But by our fore-mentioned Experiment made between *York* and *London*, we find only 367200 Feet in a Degree, being less than *Ptolomy's* by 4700 Feet, that is, by  $\frac{1}{8}$  part of a Degree, or  $\frac{1}{4}$  of a min. and little more.

*Fernelius*, a Modern Author and Learned Physician, measuring the Way by the Revolutions of a Wheel, and the Latitudes by Observation, finds in a Degree 68 Italian Miles, and 96 Paces, the Pace which he used being more than 5 of our English Feet. But because he handled not the Problem exactly, and is suspected by *Snellius* (though I think without cause) to have grounded his Conclusion rather upon the Experiment of the *Arabians* before set down (wherewith it doth nearly agree) than upon his own, we will insist no longer upon it.

We come in the last place to the Experiment of *Willebrordus Snellius*, a *Hollander*, made in the *Netherlands* about 20 Years past. We shall not need to recite the Particulars of it, being extant at large in his Book before mentioned: but in conclusion, he finds in a Degree 342000 Rhymland Feet. Now a Rhymland Foot (as he hath there shewed, comparing both together) is greater then ours, and that in such proportion, as a 1000 is to 968; (and so much, or little more, it appears to be by that Model of the Rhymland Foot printed in his Book) therefore 968 Rhymland Feet must make 1000 of ours; and hence by



the Rule of Proportion, 342000 *Rhynland* Feet will make of our *English* Feet 353306. So that there should be in a Degree only 353306 Feet, which is less than we have before found in a Degree by 13894 Feet, that is, by the  $\frac{3}{8}$  parts of a deg. or  $2\frac{1}{4}$  min. and something more. He was a Man doubtless of singular industry and knowledge, and of much exercise in the Mathematicks, and it may be was well experienced in this particular, touching the Geometrical Mensuration of Distances, and he hath bestowed much pains and diligence in this Experiment, as by his Book appeareth. But if he had by a Chain measured the Distance of his two utmost Stations (if the Ground would permit, which I suppose it would not) or at leastwise if his measured Stations had been further distant; I conceive he would have found a greater Distance in his two utmost places of Observation. But if a Man, intending to find the distance of two places, measure only the  $\frac{1}{1000}$  part of that Distance, and by that measured Line and the Angles, think to find their true Distance; whether he do it immediately from the two measured Stations, or mediately by help of others observed from them, he may easily fall into some notable Error. For tho' the Problem be exactly true in Geometrical Demonstrations, how small soever the measure be, yet it is not so in sensible and experimental Practices, by reason of the weakness of the best Eye, and the imperfection of the Instruments themselves, and in their use. And besides, that there were many Stations obliquely situate, a Man cannot always hit the just middle of that Turret, Steeple, or other mark which he observes; neither when he comes to make his Station there, can he always place his Instrument just at the concurrence of his former visual Lines, by reason of other impediments. Besides the force of the Wind in such eminent places; and moreover, that amongst so many Steeples as there are in some Towns, there a Man may at some times mistake one for another. And if there should happen no notable Error, by reason of any, or of all these Casualties, yet may two minutes, in the difference of the Latitudes of two places, be easily mistaken, especially being derived from the Latitudes of those places which are very rarely set down true to a minute.

If it be objected, That I might as well be so much mistaken in the differences of the Latitude of *York* and *London*.

I answer, It is not so likely, because I had the opportunity of observing the Summer Solstitial Altitude of the Sun in both places, wherein I had no necessary use of the Sun's Parallax nor Refraction, nor of the Table of the Sun's Declination, any of which may cause more than a minute error, in finding the Latitude of either place.

Besides,



Besides, If mine Error in those Observations should be full as much, yet would it not in the Conclusion be half so much, because the difference in Latitude of the two places of my Observation is more than twice so much as that of his.

About the Year 1672, Monsieur *Picart* published an Account in *French*, concerning the measure of the Earth, a breviat whereof may be seen in the *Philosophical Transactions*, Num. 112. wherein he concludes one Degree to contain 365184 English Feet, nearly agreeing to Mr. *Norwood's* Experiment.

But let this suffice, leaving every Man to embrace that which he shall best approve. Both our Experiments do sufficiently convince that common Errour of counting only 300000 English Feet to a Degree, besides the consent of other Observations before recited, ancient and modern.

Mr. *Snellius* hath further in that Book of his, entituled *Eratosthes Batavus*, with much diligence compared some ancient Measures, as also the Measures of sundry Foreign Countries, with the *Rhynland-Foot*; and amongst the rest, our English Foot, according to a size thereof to him sent from the Standard in *Guild-Hall*, (from whence also I had about 20 Years past, the size of that Foot, which I have used in this measure) we shall not need to repeat them all, because his Book is extant: Some of them are these following, which we here compare to our English Foot, as he hath there done to the *Rhynland*, that so any of them may be the more easily reduced into our Feet. Therefore dividing the *English* Foot into a thousand equal parts, we shew how many of those parts are contained in other Ancient and Foreign Feet.

*Ancient Feet compared with our English Foot.*

Of such parts as the <i>English</i> Foot contains		1000
The	Ancient <i>Roman</i> -Foot contains	1033
	Ancient <i>Greek</i> -Foot contains	1076
	<i>Babylonian</i> -Foot contains	1211
	<i>Alexandrian</i> -Foot contains	1240
	<i>Antiochian</i> -Foot contains	1405
	<i>Arabian</i> -Foot contains	1102



## Foreign Feet compared with our English Foot.

Of such parts as the <i>English</i> Foot contains		1000
The	<i>Ryhnland</i> -Foot contains	1033
	<i>Dort</i> -Foot contains	1085
	<i>Middleburgh</i> -Foot contains	992
	<i>Amsterdam</i> -Foot contains	934
	<i>Antwerp</i> -Foot contains	939
	<i>Lovain</i> -Foot contains	939
	<i>Hafnian</i> -Foot in <i>Denmark</i> contains	965
	<i>Paris</i> -Foot, called the <i>King's</i> Foot, contains	1090
	<i>Venice</i> -Foot contains	1157
	<i>Toledo</i> -Foot contains	896
	<i>Noremberg</i> -Foot contains	1006
	<i>Strasburg</i> -Foot contains	920

## C H A P. VII.

*Of dividing the Log-line, and reckoning the Ships way.*

**T**Here be four things, upon which the Practice of Navigation is especially grounded, namely, the knowledg of the Longitude, Latitude, Course, and Distance. Touching the Longitude, tho it may be found by the other three, yet hitherto there hath not been delivered any general Rule true and practicable, whereby the Longitudes of places might be immediately and ordinarily found of themselves. The Latitudes of places may immediately be found by Observation of the Sun and Stars, as we have formerly shewed in the Appendix to the *Doctrine of Triangles*: The Course by the Compass, the Variation being duly observed, wherein we have many good Mariners very expert, this we have also handled in the *Doctrine of Spherical Triangles*. The Distance run, is found of it self by the *Log-line*, whereof we are here to speak.

The ground of finding the distance run by the *Log-line* is meerly conjectural, being founded upon this Opinion, That 5 of our Feet make a Pace, and 1000 such Paces make a Mile, and that 60 such Miles make a Degree; so that a Degree should contain 300000 of our Feet.



Feet. But it appears not only by this Experiment, but even by all others that were diligently taken, and their measures to us known, that there is a greater number of our Feet contained in a Degree.

There be three things (as I conceive) that have caused this Error to be commonly perceived and tolerated. The one, for that it doth somewhat counterpoise another contrary Error in the Practice of Navigation, namely, in the use of the *Plain Chart*; for the Error which is there committed by making every Parallel equal to the Equinoctial, and so every Degree in them greater than they should be, is something moderated by this Error; whereby the measure of a Degree is esteemed less than indeed it is.

For instance; It is evident by the Globe, that the Meridians concurring in the Poles grow nearer and nearer together, as they grow towards the Poles; insomuch, as if two Meridians be distant in the Equinoctial 10 Degrees, that is 600 Miles, the same Meridians in the Latitude of 35 deg. will be distant little more than 490 Miles. Now if unto every Mile we account according to the former Experiment 6120 Feet, then is the distance of those two Meridians in that Parallel 3000000 Feet. In like sort the *Plain Chart*, 10 deg. of that Parallel (as of all others) is made equal to 10 deg. of the Equinoctial or Meridian; so that the distance of these two Meridians will upon the *Plain Chart* be 600 Miles, but one of these Miles contains only 5000 Feet, so that the distance is but 3000000 Feet, equal to the former.

And Although these Errors in other cases do not justly balance one another, as in this Example, yet that of the *Plain Chart* is always something moderated by this other, and so much the more, by how much they are nearer to the foresaid Latitude. I grant that is only so when the Course is near unto the East or West Points; but withal, I say, that this kind of reckoning is (in a manner) then only used: For he that runs any Course near the Meridian southerly or northerly, hath a more certain way of reckoning, namely his Latitude, which he finds daily by the Observation of the Sun and Stars, upon which he will depend, either neglecting, or at least not regarding his dead reckoning. Yea, (if it may be) never casting the *Log* so much as once in such a Voyage, having a more sure ground for his Reckoning. But in a Course that is near the East and West (inasmuch as there is no way discovered for finding the Longitude) he is driven of necessity to make use of this dead Reckoning.

We might add moreover, that the principal Voyages of this kind, I mean of those which consist of Courses much Easterly and Westerly, as



to and from the *West' Indies*, and the Parallel of *Cape bon Esperance*, are near unto this Latitude of 35 deg. so that as some of them are more Southerly, others of them are more Northerly.

But to insist no longer upon this, I suppose a second Cause to be, or that Men commonly desire to have their Reckoning before their Ship (as they say) that they fall not with a place before they look for it: And this comes to pass, whilst the Miles are accounted less in measure, and so more in number than they are indeed.

And thus, though there may seem to be some commodity in these Errors, especially when they do nearly ballance one another; yet because they seldom do so, but always leave Men in uncertainties, and oftentimes in great perplexity and danger, it is much safer and better to reject them both, and to embrace those ways which are evidently grounded upon Truth, though there may be in them some more difficulty at the first. Yet I confess, that he which reforms one and not another, may sometimes err so much the more thereby. And I doubt not, but many would reform them both, if they could certainly do so.

Therefore a third cause of admitting and retaining this Error seems to be, for that there hath been no way delivered from evident and certain Grounds for the rectifying of it. I doubt not but many have found Errors in their Reckonings, arising from hence, that they account only 300000 of our Feet to a Degree; but not knowing certainly where to lay the fault, have imputed it sometimes to ill Steerage, otherwhiles to the variation of the Needle, or to some mistake in their Reckonings, or to some Error in their Plots, or to some Current, as such other accident, and so the Error hath rested unreformed. Wherefore although the practical performance of this Problem for finding the Circumference of the Earth, or the quantity of a Degree on the same, have many singular uses which I cannot now touch; yet that which amongst the rest I chiefly aimed at, was, that he might have a more sure and evident ground for dividing the *Log-line*, and for reckoning the Ship's way or distance run more truly upon any Rhomb, or Point of the Compass, than formerly.

And now to apply it to this purpose; we have noted before (Chap. 2.) that by the Experiment there expressed, we find in a Degree on the Circumference of the Earth and Sea, 367200 of our English Feet. Wherefore retaining still the same division of degrees into 60 Miles, or 20 Leagues (as hath been formerly used) a Mile will contain 6120 Feet, or 1020 Fathom: and so a League contains 18360 Feet, or 3060 Fathoms, for dividing 367200 by 60, the Quotient



is 6120, &c. Thus then 60 Miles being a Degree, every Mile is 6120 Feet.

Now supposing the time of the running out of the *Log-line* to be measured by a half-minute Glass, if we observe how many Feet or Fathoms she runs in half a Minute, we may thereby find her way for an hour, or 4 hours, or for any other time proposed.

As, admit there runs out of the *Log-line* in half a minutes space 51 Feet, or  $8\frac{1}{2}$  Fathoms, and you would know what way the Ship makes every hour after the same rate; say by the Rule of Proportion,

If  $0\frac{1}{2}$  Minutes give 51 Feet,  
what gives 60 Minutes? Or,

If 1 Minute gives 102 Feet,  
what gives 60 Minutes?

And so multiplying, you shall find 6120 Feet, which is one Mile :  
Or, if you would find her way for four hours, which is 240 Minutes; say,

As 1 Minute is in proportion to 240 Minutes;

So are 102 Feet to 24480 Feet, or 4 Miles.

Or, if you would have in Fathoms; say,

A 1 Minute is in proportion to 240 Minutes;

So is 17 Fathoms to 4080 Fathoms, the Ships way in four hours.

The like is to be conceived, if your Glass be for any other quantity of time above or under half a Minute.

Some have thought that the Way which the Ship maketh, may be known to an old Sea-man by experience (as they say) that is, by conjecture; which Opinion makes some neglect the use of the *Log*. lest they should be accounted young Sea-men. But as he that rides often will have some near guess how far the pace he rides will carry him in an hour (because he hath often observed it formerly;) so he which hath often sailed, and kept an account of the Ship's way by the *Log*, will be able to give some near estimate of her way without the *Log*. But it is incident to some Men to have such a conceit of this their estimate, that they think it more certain than the Rule it self, from whence it is derived, especially if it chance to answer their expectation at some times.

It is thought also that the Ship's way may be known by two marks on the Ship's side. But this is doubtless very certain, both by reason of the shortness of the Time, and in respect of the dead Water (as they call it) by the Ships side. For the Water which is near the Ship, is drawn  
F along



along with the Ship in her motion, and so much the more, by how much it is nearer.

But if any desire to make trial of this way, it is to be considered, that 17 Foot is  $\frac{1}{8}$  part of a Mile, and 10 sec. of a minute is  $\frac{1}{6}$  parts of an hour: Therefore if there be two marks on the Ship's side distant 17 Feet, if the Ship run the distance of these two marks in 10 sec. she runs a Mile in an hour, if in 5 sec. two Miles an hour, if she runs that distance in 2 sec. she runs 5 Miles in an hour. And so always dividing 10 sec. by the number of sec. in which the Ship runs that distance, the Quotient shews the Miles and parts of a Mile run in an hour.

But if the distance of those two marks be 34 Feet, if she runs it in 20 sec. it is after a Mile an hour; if in 10 sec. two Miles an hour; if in 5 sec. four Miles an hour: and so always dividing 20 sec. by the number of seconds, in which the Ship runs that distance, the Quotient shews how many Miles the Ship runs in an hour. As if the Ship run that distance of 34 Feet in 8 sec. then dividing 20 by 8, the Quotient is  $2\frac{1}{2}$ ; shewing that she runs  $2\frac{1}{2}$  Miles in an hour. Or, if you can conveniently make the distance of the two marks on the Ship's side to be 51 Feet (for the further they are distant the better) then if the Ship run that distance in 30 sec. it is a Mile an hour, if in 10 sec. it is 3 Miles an hour; and so always dividing 30 sec. by the number of seconds, in which the Ship is running that distance, the Quotient shews after that rate how many Miles the Ship runs in an hour.

Otherwise you may do thus: Divide 17 Feet into 10 parts, and set as many of those parts on the Ship's side as conveniently you may, which according to the Ship's length will be more or fewer. Then when the Ship runs one of those parts in a sec. of time, it is a Mile an hour; when two, it is two Miles an hour; when five, it is five Miles an hour. And in general, if you divide the number of parts run by the time of running accounted in sec. the Quotient shews what number of Miles after that rate are run in an hour.

As if she run thirty of those parts in five seconds, it is six Miles an hour; for dividing 30 by 5, the Quotient is 6; so if she run forty two of those parts in 10 seconds, dividing 42 by 10, the Quotient is  $4\frac{2}{10}$ , which sheweth the Ship's way at that time to be after the rate of four Miles and two tenths of a Mile in an hour.

But for keeping this Account of Time, it may be done either by a Sand-glass for that purpose, or by a pronouncing certain words of numbers: as the time wherein a Man tells twice 60, pronouncing every number as fast as he can conveniently and distinctly, is about a minute;



so that the time wherein a Man is numbring 60, is half a minute, or 30 seconds; and whilst a Man is numbring two (as one and twenty, two and twenty) is a second; and so whilst a Man is numbring from twenty to thirty, is five seconds; from twenty to forty ten seconds, &c. but in numbring from one and twenty, you may observe the same times as in numbring from one and twenty to forty, and this will not be hard to do; for whilst a Man pronounceth one and twenty, two and twenty, three and twenty, &c. there remains a certain impression in the Fantastie, whereby a Man is able in the same time to pronounce one, two, three, &c. And altho this Rule of numbring twice 60 for a minutes space be not general to all Men, because some are swifter or slower in their pronounciation than others; yet after this Example, a Man making trial, may frame a Rule to himself, whereby he may come something near the Truth.

But leaving these, we come to the division of the *Log-line*, according to the half-minute Glass, which is more usual and certain. And considering that half a minute, is of an hour the  $\frac{1}{12}$  part, therefore the Ship's way running 51 Feet in half a minute, is a Mile an hour; if she run twice so much, that is, 102 Feet in half a minute, it is two Miles an hour; if thrice so much, it is three Miles an hour: And in general, how many times 51 Feet she runs in half a minute, so many Miles is her way for an hour. Therefore leaving half a score Fathoms, or more, from the *Log*, that so it may be out of the Eddy of the Ship's wake, before you begin to account or turn the Glass; if there you make a Mark for the beginning, and so 51 Feet from thence a Mark of one Knot, and 51 Feet further a Mark of two Knots, and 51 Feet further (that is, 153 Feet from your first Mark) another Mark of three Knots; and so proceeding, look how many Knots are veered out in half a minute, so many Miles is the Ship's way for an hour. Now for that which is veered out more above the just measure of the Knot or Knots, you may allow for every 5 Feet the tenth part of a Mile almost. As admit she run 5 Knots and 25 Feet in half a minute; then is her way according to  $\frac{5}{10}$ , or 5 Miles and a half in an hour; if 6 Knots and 10 Feet, it is  $6\frac{1}{3}$  Miles in an hour, &c.

But according to the common Opinion of 5000 Feet to a Mile, and 60 such Miles to a Degree, there should be something less than 7 Fathom, namely,  $41\frac{2}{3}$  Feet to a Knot.

And although he which veers the *Log-line* be careful to overhale it so slack, that it may not draw forward the *Log*, yet (no doubt) it doth lose some way, following the Ship a little as it is drawn by the Line, and



withal by the Eddy of the Ship's wake, and sometimes also is cast forwards by the Wind and Waves, when they come after the Ship: so that for these Causes, it is like, there may sometimes be allowed three or four Fathoms more than is veered out; but this (as a thing mutable and uncertain) being sometimes more, sometimes less, cannot be brought to any certain Rule, but such allowance may be made as a Man in his Experience and Discretion shall think fit.

If you would divide the *Log-line* so as it might give the Ship's way in *Centesms*, or the hundredth part of a Degree, and fit it to a half-minute Glass; Then seeing the hundredth part of a Degree is 3672 Feet, and the  $\frac{1}{120}$  part thereof is  $3\frac{1}{2}$  Feet; if you begin at the mark at which you mean to turn the Glass, and measure from thence 30 Feet, and three fifth parts of a Foot, you may there place 1 Knot; and thence again measuring 30 Feet, and three fifth parts of a Foot, there place two Knots; and so proceeding at the end of every 30 Feet and three fifths, adding a Knot, the number of Knots which run out in half a minute, is the number of *Centesms* which the Ship runs in an hour. As suppose there run out 10 Knots in half a minute, then the Ship's way is according to 10 *Centesms* of a Degree in an hour, that is, the tenth part of a Degree, or 6 Miles. And so every 3 Foot above the just measure of Knots, is near the tenth part of a *Centesm*, or the thousandth part of a Degree. As if there run out of the *Log-line* 5 Knots and 12 Feet, then the Ship's way for an hour is 5 *Centesms*, and four tenth parts of a *Centesm*: the like is to be understood of others.

And after the form of these Examples you may divide the *Log-line* for any other quantity of Time, more or less than half a minute, or for any other parts of a Degree proposed.

Thus have we handled the division of the *Log-line*, according to the measure before found of 367200 English Feet in a Degree. But because (as I have before shewed) the Ship's way is commonly more than by the *Log-line* it appears to be, and every Man desires to have his Reckoning something before his Ship, that he fall not with a place unexpected; for these, and such other causes, and for the rotundity of the number, if any Man think it more safe and convenient in Sea-reckonings, he may abate one in 51, and so assign to a Degree only 360000 Feet, and consequently to a Mile 6000 *English* Feet.

And upon this ground, if in half a minute there run out 50 Feet of the *Log-line*, it is a Mile an hour; and so if 100 Feet run out in a minute.

For, as 1 minute is in proportion to 60 minutes:

So is 100 Feet to 6000.

And



And so forasmuch as 25 Feet is  $\frac{1}{4}$  part of a Mile, and 15 seconds is also  $\frac{1}{4}$  part of an hour. Therefore if there be two marks on the Ship's side distant 25 Feet, if the Ship run the distance of these two marks in 15 seconds, it is after the rate of a Mile an hour; if in 5 seconds, it is 3 Miles an hour; and so always dividing 15 seconds by the number of seconds in which the Ship runs that distance; the Quotient sheweth the Miles and parts of a Mile run in an hour. But if the distance of these two marks be 50 Foot, then if she run it in 30 seconds, or half a minute, it is a Mile an hour; if in 10 seconds, three Miles an hour; if in 5 seconds, six Miles an hour (for 30 divided by 5, the Quotient is 6.) And so always dividing 30 seconds by the number of seconds, in which the Ship runs that Distance; the Quotient shews how many Miles she runs in an hour, &c.

Otherwise, If you make a mark on the Ship's side at every 20 Inches, then when the Ship runs one of these parts in a second of time, it is a Mile an hour; when five, it is five Miles an hour; if she run eighteen of these parts in three seconds, it is six Miles an hour: For dividing 18 by 3, the Quotient is 6. And in general, if you divide the number of the parts run, by the number of seconds spent in running, the Quotient shews the Ship's way in Miles for an hour.

But for dividing the *Log-line* according to this ground of 6000 Feet in a Mile, if you intend to use it with a half-minute Glass, then because half a minute is  $\frac{1}{120}$  part of an hour, and 50 Feet is also the  $\frac{1}{120}$  part of a Mile; therefore when the Ship runs 50 Feet in half a minute, her way is after the rate of a Mile an hour; if 100 Feet in half a minute, it is two Miles an hour, &c.

Therefore half a score Fathoms or more from the *Log*, you may make a mark, and beginning from thence measure 50 Feet, and there make the first Knot, and 50 Foot farther two Knots, and 50 Foot farther three Knots: And so proceeding, look how many Knots run out in half a minute, so many Miles is the Ship's way for an hour: and every 5 Feet more besides the Knots, is a tenth part of a Mile; as if there run out 6 Knots and 20 Feet in half a minute, the Ship's way is after the rate of  $6\frac{2}{10}$  Miles in an hour, &c.

And so if the Glass were for any other time more or less than half a minute, you may make the distance of your Knots proportional: As if it were for 20 seconds, then because 20 seconds is of an hour the  $\frac{1}{3}$  part, I divide a Mile, which is 6000 Feet, by 180, and the Quotient is  $33\frac{1}{3}$ ; therefore there must be a Knot at every 33 Feet and 4 Inches.



If your Glas be 36 seconds, which is  $\frac{1}{60}$  part of an hour, divide 6000 by 100, the Quotient is 60; shewing that there must be 60 Feet to every Knot; and then every 6 Foot over and above the Knots, is a tenth part of a Mile more.

And so it is better that your Glas be more than half a minute, rather than less; and the more the better, provided that there run out no more Line than you may hale in again, without danger of breaking.

Lastly; If you would so divide the *Log-line*, that it might shew the Ship's way in *Centesims* of a Degree, and fit it to an half-minute Glas. Then forasmuch as the hundredth part of a Degree is 3600 Feet, and the  $\frac{1}{20}$  part thereof is 30 Feet; therefore beginning at the mark whereat you intend to turn the Glas, measure from thence 30 Feet, and there make one Knot, and at 30 Feet farther two Knots, &c. Then look how many Knots run out in half a minute, so many *Centesims* of a Degree is the Ship's way for an hour. And so if the Glas be 36 seconds, then every Knot must have 36 Feet, &c.

Now if a Man sailing between any two places which lie near East and West one from another, have kept his Reckoning by Course and Distance, using a *Log-line* so divided, that it have a Knot at every 7 Fathoms (as many do) and would reduce the Distance of those two places so found, to their Distance in such Miles, as these of 60 to a Degree, each containing (as we have said) 6000 Feet; the proportion in number of those to these, is as 6 to 5, for six of them make five of these.

As, admit a Man in his dead Reckoning, using such a *Log-line* as hath a Knot at every 7 Fathoms, and for every Knot running out in half a minute, he accounts the Ship's way to be so many Miles an hour; and according to such a Reckoning, suppose he find the Distance of two places to be 1224 Miles, or 408 Leagues, and would know the Distance of the same places in Miles of 6000 Feet to a Mile, which is according to a *Log-line* that hath a Knot at every 50 Feet. Say then by the Rule of Proportion:

As the number 6	<i>Co. ar.</i>	_____	9.22185
is in proportion to 5		_____	0.69897
So is the number of Miles given, 1224		_____	3.08778
to the number of Miles required, 1020		_____	3.00860

Which 1020 is the Distance of those two places, in such Miles whereof 60 make a degree. Or to find the same in Leagues, the Proportion is: As 6 to 5, so is 408 Leagues to 340 Leagues.

And thus may the Distance of places be found in such Miles, whereof 60 make a degree, especially if with the Distance expressed in the *Plain Chart*,



*Chart*, you compare the Reckonings of some skillful Mariners that have failed from the one to the other. But thus to endeavour a Reformation of the *Plain Chart*, were a Labour to little purpose; for there the correcting of the true situation of two places, in respect of one another, is oftentimes an occasion that the same places are the more falsely situate in respect to others. Like as if there were two places 8 Miles stant, and it was required to place a third three Miles from either of them; here, if we set the third in the middle, it will be four Miles distant from either: But if (attempting to mend that Error) we make the third to be three Miles from the first, then will it be five Miles from the second. And thus unavoidably, the mending of the one is the marring of the other, because the thing proposed is not possible.

And such is the Error of the plain or common *Sea-Chart*, representing the Earth and Sea, not as a Spherical, but as a Plain Superficies; not as if the Meridians did concur in the Poles, but as if they were always parallel one to another. So that the Graduation and Projection being such, the Situations and Distances of places cannot be generally and truly expressed therein.

But the Graduation and Projection of *Mercator's Chart*, agreeing without sensible Error with the Globe, there may in that be described all or any parts of the World, according to their Longitudes, Latitudes, Courses, and Distances, as truly, and far more conveniently for the Mariner's use, than upon the Globe it self; and upon such a *Chart* so described, a Reckoning may be truly kept, and any Error committed may easily be discerned and amended. Whereas on the *Plain Chart*, if a Man find his Reckoning to disagree, he is so far from knowing how to amend it, that he can seldom conjecture where the fault was.

The neglect and want of these *Charts* hath been, and is a great imperfection in *Navigation* and *Geography*. For howsoever there be some which do daily set forth for sale, Maps of the World, and of the parts thereof, according to this Projection; yet to have them truly such, and fit for Navigation, requires in the Author or Maker of them good Knowledge, and some competent Ability of his own, or Aid from others; with a greater love to the Truth, than to his own Profit; which may induce him to bestow such Industry, Time and Expence, as I have formerly noted to be requisite in such a Work.

For the furtherance whereof, and of the Practice of Navigation in general, I shall endeavour in the two next Chapters to shew a methodical and orderly way of keeping a Reckoning at Sea, more distinctly and exactly than hath been formerly used, and such as may aptly be set  
down



down in any *Chart*, and applied in the three principal kinds of Sailing; namely according to the *Plain Chart*, or *Mercator's*, or according to the Arch of a *Great Circle*. And by a few Reckonings truly set down according to this form, the Maps of the World, and of the parts thereof, might be much reformed.

## CH A P. VIII.

*A formal and exact way of setting down and perfecting a Sea-reckoning.*

**A**Ltho the Course and Distance cannot be so truly and certainly known as the Latitude may be; yet we must endeavour in these also to come as near the Truth as may be, the rather, for that some Reckonings must necessarily depend wholly upon them. And to that end, those which in their Voyages at Sea, have occasion to run far upon any Course or Courses near the Meridian, may do well to make trial of that which I have formerly set down, touching the quantity of a Degree on the Earth and Sea in our known Measure; and especially in *East-Indian* Voyages; sailing from the *Lizard* in the West part of *England* to *Cape bon Esperance* in *Africk*, they have opportunity of making an ample Experiment hereof.

But leaving this to the Practice of the skilful and industrious Seaman, we come now to shew an orderly and exact way of framing and keeping a Reckoning at Sea; for which purpose I have made the Table following, which sheweth how much a Ship is more Northerly or Southerly, and how much more Easterly or Westerly, by sailing upon any Point or half-Point of the Compass, any number of Miles proposed.

The like Table I made many years since, and taught the Use of it in *Navigation*; whether it were then used by any other, I know not, I had it of no Man; but this I speak, that if any Man claim the first making and use of such an one, he may have it.

The Ground of making this Table is the same with the former. For as Radius is in proportion to the Distance run, so is the Sine Complement of the Rhomb, to the Distance of North or South; and so is the Sine of Rhomb, to the Distance of East or West. Therefore here for 10 Miles upon any of the four Points from the Meridian, we set in the second Column the Sine Complement of that Point (reduced into Degrees) and in the third the Sine thereof. As the second Rhomb or Point from the Meridian, being 22 degrees 30 minutes, the Sine Complement thereof

which



which is 9239 set in the second Column against 10; and the Sine thereof 3827, I set here in the third Column: and having done thus for 10 Miles in every Column, the rest may be easily drawn from them.

As in the second Column, for the first half Point against 10 Miles finding 9952, I set the half thereof, namely 4976 against 5 Miles, and the tenth part thereof, namely 995 against one Mile, which doubled, or added to it self, is 1990, to be set against 2 Miles, whereto adding the same 995, the Sum is 2985 for 3 Miles; and so for the rest.

And thus for every Point and half-Point from the Meridian, there are three Columns: In the first whereof there is set down a number of Miles run upon that Point or half-Point; the second sheweth how much the Latitude is altered, that is, how much you are more Southerly or Northerly, by running so far upon that Point or half Point; the third, how much you are more Easterly or Westerly, by running that Course and Distance.

The numbers set in every first Column, from 1 to 10, are also to be understood from 10 to 100, or from 100 to 1000, and the Figure in the fourth place of the second and third Columns, answer to the Figure in the first. As admit a Ship runs South and by West, (that is, South, one Point Westerly, 165 Miles) I set down this number thus,

and looking in the Columns of the first Rhomb against 10 (which may be understood to be 100) I find against it in the second Column 981 almost, and in the third 195; also against 60 (that is, 6) in the first Column, there

	100	981	195
S. W. 1.	60	588	117
Point.	5	49	10
	165	161.8	32.2

is 588 in the second, and 117 in the third: also against 5 in the first Column, there is 49 in the second, and almost 10 in the third.

These set down, and summ'd up, as here appeareth, shew that a Ship running S. by W. 165 Miles, is to the Southwards of the place from whence she departed 161 Miles, and 8 tenth parts of a Mile; and to the Westwards 32 Miles, and 2 tenth parts of a Mile. If you desire more exactness, you may use all the places for the first or greatest number, which is here 100.

As in this second Example, where the Southerly Distance is  $161 \frac{8}{10}$  Miles, and the Westerly  $32 \frac{2}{10}$  Miles.

	100	9808	1950
S. W. 1.	60	5885	1170
Point.	5	490	97
	165	161.83	32.17



A Table of the Northing or Southing, Easting or Westing of every Rhomb and half Rhomb from the Meridian, according to the number of Miles run upon that Rhomb.

	1 Poi.	7 $\frac{1}{2}$ Poi.	1 Poi.	7 Poi.	15 Poi.	6 $\frac{1}{2}$ Poi.	2 Poi.	6 Poi.
M.	5.37 $\frac{1}{2}$	84.22 $\frac{1}{2}$	11.15	78.35	16.52	73.7 $\frac{1}{2}$	22.30	67.30
1	995	98	981	195	957	920	924	383
2	1990	196	1962	390	1914	580	1848	766
3	2986	294	2943	585	2871	870	2772	1148
4	3981	392	3923	780	3827	1161	3696	1531
5	4976	490	4904	975	4784	1451	4620	1914
6	5971	588	5885	1170	5741	1741	5544	2297
7	6966	686	6866	1365	6698	2031	6468	2680
8	7961	784	7846	1560	7655	2321	7392	3062
9	8957	882	8827	1755	8612	2612	8315	3445
10	9952	980	9809	1950	9569	2902	9239	3827

	2 $\frac{1}{2}$ Poi.	5 $\frac{1}{2}$ Poin.	3 Poin.	5 Poin.	3 $\frac{1}{2}$ Poi.	4 $\frac{1}{2}$ Poi.	4 Poin.	4 Poin.
M.	28.7 $\frac{1}{2}$	61.52 $\frac{1}{2}$	33.45	56.15	39.22 $\frac{1}{2}$	50.37 $\frac{1}{2}$	45.00	45.00
1	882	471	831	556	773	634	707	707
2	1764	942	1663	1111	1546	1269	1414	1414
3	2646	1414	2494	1667	2319	1903	2121	2121
4	3528	1885	3326	2222	3092	2538	2828	2828
5	4410	2357	4158	2778	3865	3172	3535	3535
6	5292	2828	4989	3334	4638	3806	4242	4242
7	6174	3300	5820	3890	5411	4440	4949	4949
8	7056	3771	6652	4445	6184	5075	5656	5656
9	7937	4243	7483	5000	6957	5710	6364	6364
10	8819	4714	8315	5556	7730	6344	7071	7071

A larger Example may be that before set down in the last Problem of sailing by a great Circle, from *Summer Islands* to the *Lizard*, Pag. 170, &c. of the *Doctrine of Triangles*.

As admit I sail from thence, First, N E.  $\frac{1}{2}$  a Point Easterly 600 Miles; then N. E. by E. 300 Miles; E. N. E. half a Point Northerly



495 Miles ; E. N. E. 390 Miles ; E. N. E.  $\frac{1}{2}$  a Point Easterly 264 Miles ; N. by E. 210 Miles ; East 951 Miles. These Courses and Distances I set down in such form as here appeareth ; where in the first Column there is expressed the Course or Point of the Compass upon which a Man sails ; in the second Column, the Distance of the Rhomb from the Meridian ; in the third Column, the Distance run upon that Point ; in the rest, the Difference of Latitude and Departure from the Meridian in Miles, and tenth parts of a Mile.

Course.	Rumb from the	Dist. miles.	North.	South.	East.	West.
N. E. $\frac{1}{2}$	North.					
Po. E.	Easterly.	600	380.6		463.8	
	$4 \frac{1}{2}$ P.					
N. E. by E.	N. East.	300	166.7		249.4	
	5 Point.					
E. N. E. $\frac{1}{2}$	N. East.	400	188.5		352.8	
Po. N.	$5 \frac{1}{2}$ Po.	90	42.4		79.4	
		5	2.4		4.4	
E. N. E.	N. East.	300	114.8		277.3	
	6 Po.	90	34.4		83.1	
E. N. E. $\frac{1}{2}$	N. East.	200	58.0		191.4	
Po. E.	$6 \frac{1}{2}$ Po.	90	17.4		57.4	
		4	1.2		3.8	
E. by N.	N. East	200	39.0		196.2	
	7 Point.	10	2.0		9.8	
		900			951.0	
East.	East.	50				
		1				
		3210	1047.4		2919.7	

(In all which it is to be conceived, that all the *Variations* are allowed) so that at the Foot of this Reckoning, I find the Sum of the North Column to be 1047  $\frac{4}{10}$  Miles, and the Sum of the East Column 2910 Miles almost ; the first, namely 1047 Miles converted into degrees, is 17 deg. 27 min. the difference of Latitude, which added to the Latitude of *Summers Islands* 32 deg. 25 min. (where this Reckoning began)



the Sum is 49 deg. 32 min. which is the Latitude of this place where this Reckoning endeth. So that according to this Account, the Ship is run into the Latitude of 49 deg. 52 min. and hath altered her Longitude to the Eastwards 2920 Miles, of such Miles whereof 60 make a Degree of a great Circle.

Therefore if you set down this Reckoning on the *Plain Chart*, you must make a Point in the *Chart* that may be in the Latitude of 49 deg. 52 min. and to the Eastwards of *Summers Island*, (where this Reckoning began) 2920 Miles; that is, you must run a Parallel (with your Compasses or otherwise) on your *Chart* in the Latitude of 49 deg. 52 min. and cross the same by a Meridian, which may be to the Eastwards of the Meridian of *Summers Islands* 2920 Miles; and so the Point of the Intersection of this Parallel and Meridian, is the *Traverse-Point*, or Point in the *Chart* representing the place where the Ship is in the end of this Reckoning.

But if you set down this Reckoning on *Mercator's Chart*, you must also find a Point that may be in the Latitude of 49 deg. 52 min. and may likewise be to the Eastwards of *Summers Islands* 2920 Miles, which is done by running with your Compasses a Parallel in the Latitude of 49 deg. 52 min. and crossing the same by a Meridian, which may be to the Eastward of the Meridian of *Summers Islands* 2920 Miles, the Point of the Intersection of this Parallel with that Meridian, is the *Traverse-Point*, representing in the *Chart* the place where the Ship then is.

For it is to be conceived in this *Chart*, that the degrees of the Meridian intercepted between the Latitudes of two places, are as a Scale for those places, to measure not only their difference of Latitude, but likewise their distance in their Rhomb, as also the distance of their Meridians.

But because it often falls out, that in sailing from place to place, a Ship runs not near the Rhomb of the two places by many hundred Miles, especially in sailing by the Arch of a *Great Circle*, which is the most exquisite manner of sailing, and wherein a Man shifts his Course often, and runs much farther in one Latitude than in another, as by the former Example may appear. Therefore once in three or four days, or so often as you alter your Course much, you may transfer or set down your Reckoning out of your Book in your *Chart*. As in transferring the former Example, you may set down the Northing and Easting of every of the Courses severally: but for brevity sake we will bring them into three parts; and so also we shall not much err.

And

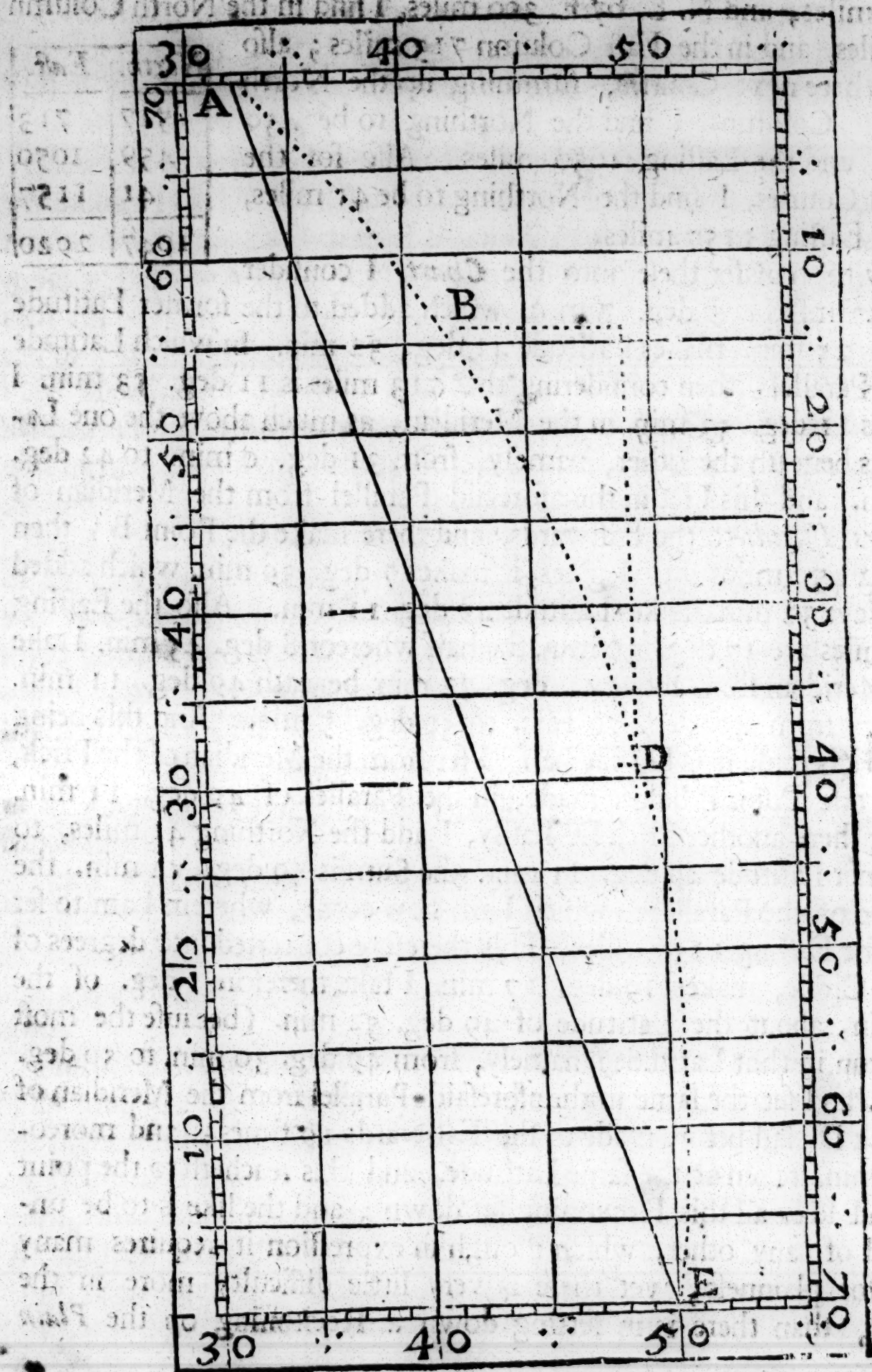


And thus for the two first Courses, namely, N. E.  $\frac{1}{2}$  a Point Easterly 600 miles, and N. E. by E. 300 miles, I find in the North Column 547 miles, and in the East Column 713 miles; also for the three next Courses, summing up the North and East Columns, I find the Northing to be 459 miles; and the Easting 1050 miles. Also for the two last Courses, I find the Northing to be 41 miles, and the Easting 1157 miles.

North.	East.
547	713
459	1050
41	1157
1047	2920

Now to transfer these into the *Chart*, I consider that 547 miles is 9 deg. 7 min. which added to the former Latitude 32 deg. 25 min. makes Latitude 41 deg. 32 min. In which Latitude I run a Parallel; then considering that 713 miles is 11 deg. 53 min. I take this 11 deg. 53 min. in the Meridian, as much above the one Latitude as beneath the other, namely, from 31 deg. 0 min. to 42 deg. 53 min. and this I set in the aforesaid Parallel from the Meridian of *Summers Islands* to the Eastwards, and there make the Point B; then reducing 459 miles into degrees, it makes 7 deg. 39 min. which added to 41 deg. 32 min. makes Latitude 49 deg. 11 min. Also the Easting 1050 miles are 17 deg. 30 min. the half whereof 8 deg. 45 min. I take in the Meridian from above 41 deg. 32 min. beneath 49 deg. 11 min. namely, from 41 deg. 20 min. to 50 deg. 5 min. And this being doubled (because it is but the half) I set from the Meridian of the Prick, or Traverse Point B before made, in the Parallel of 49 deg. 11 min. making there another Prick D. Lastly, I add the Northing 41 miles, to the former Latitude 49 deg. 11 min. the Sum is 49 deg. 52 min. the Latitude of the Parallel to which I am now come, wherein I am to set down the Easting 1157 miles. This therefore converted into degrees of a great Circle, makes 19 deg. 17 min. I take therefore 1 deg. of the Meridian, about the Latitude of 49 deg. 52 min. (because the most part is run in that Latitude) namely, from 49 deg. 30 min. to 50 deg. 30 min. and set the same in the aforesaid Parallel from the Meridian of the prick D. last before made to the Eastwards 19 times; and moreover 17 min. taken at the same Latitude, and this reacheth to the point E. And so is all this Reckoning set down; and the like is to be understood of any other, which though in expression it requires many words for plainness, yet there is very little difficulty more in the Practice, than there is in setting down a Reckoning on the *Plain Chart*.







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## C H A P. IX.

*A more ample Example, together with a larger Table for the keeping a Reckoning at Sea.*

**H**AVING thus (in a more general manner) shewed how to set down a Reckoning of the Ship's way for every Point and half-Point of the Compass, this to some Men might seem sufficient: But because a Ship doth not always make her way good as she lies, nor doth her Leeward-way always fall justly upon a whole Point, or half-Point, or quarter: And moreover, considering that though a Ship steer away upon any Point of the Compass, yet her true way, by reason of the variation of the Needle, may swerve from that Point towards the one side, or towards the other 3 or 4 degrees, or more or less, and not always a Point, or half-Point, or quarter; therefore I have thought it requisite to set down the *Table* following to every single degree; and that a Man might the more readily with one or two Entrances have his desire, I have also enlarged the number of Miles unto 100. The Ground and way of making this *Table*, differs not from the former, and it is to be used almost in the self-same manner; wherefore we shall use the more brevity in handling it.

Here followeth a *Table* of the Northing or Southing, Easting or Westing of every degree from the Meridian, according to the number of Miles run upon that degree; which for brevity sake we call.

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Diff.	1 Deg.		Diff.	1 Deg.		Diff.	1 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	1.0	0	35	35.0	6	69	69.0	1.2
2	2.0	0	36	36.0	7	70	70.0	1.2
3	3.0	0	37	37.0	7	71	71.0	1.3
4	4.0	1	38	38.0	7	72	72.0	1.3
5	5.0	1	39	39.0	7	73	73.0	1.3
6	6.0	1	40	40.0	7	74	74.0	1.3
7	7.0	1	41	41.0	7	75	75.0	1.3
8	8.0	1	42	42.0	7	76	76.0	1.3
9	9.0	2	43	43.0	8	77	77.0	1.4
10	10.0	2	44	44.0	8	78	78.0	1.4
11	11.0	2	45	45.0	8	79	79.0	1.4
12	12.0	2	46	46.0	8	80	80.0	1.4
13	13.0	2	47	47.0	8	81	81.0	1.4
14	14.0	2	48	48.0	9	82	82.0	1.4
15	15.0	3	49	49.0	9	83	83.0	1.5
16	16.0	3	50	50.0	9	84	84.0	1.5
17	17.0	3	51	51.0	9	85	85.0	1.5
18	18.0	3	52	52.0	9	86	86.0	1.5
19	19.0	3	53	53.0	9	87	87.0	1.5
20	20.0	4	54	54.0	10	88	88.0	1.5
21	21.0	4	55	55.0	10	89	89.0	1.6
22	22.0	4	56	56.0	10	90	90.0	1.6
23	23.0	4	57	57.0	10	91	91.0	1.6
24	24.0	4	58	58.0	10	92	92.0	1.6
25	25.0	4	59	59.0	10	93	93.0	1.6
26	26.0	5	60	60.0	11	94	94.0	1.7
27	27.0	5	61	61.0	11	95	95.0	1.7
28	28.0	5	62	62.0	11	96	96.0	1.7
29	29.0	5	63	63.0	11	97	97.0	1.7
30	30.0	5	64	64.0	11	98	98.0	1.7
31	31.0	5	65	65.0	12	99	99.0	1.7
32	32.0	6	66	66.0	12	100	100.0	1.8
33	33.0	6	67	67.0	12	200	200.0	3.5
34	34.0	6	68	68.0	12	300	300.0	5.3
Diff.	Dep.	Lat.	Diff.	Dep.	Lat.	Diff.	Dep.	Lat.
	89 Deg.			89 Deg.			89 Deg.	



Dif.	2 Deg.		Dif.	2 Deg.		Dif.	2 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	1.0	.0	35	35.0	1.2	69	69.0	2.4
2	2.0	.1	36	36.0	1.3	70	70.0	2.4
3	3.0	.1	37	37.0	1.3	71	71.0	2.5
4	4.0	.1	38	38.0	1.3	72	72.0	2.5
5	5.0	.2	39	39.0	1.4	73	73.0	2.5
6	6.0	.2	40	40.0	1.4	74	74.0	2.6
7	7.0	.2	41	41.0	1.4	75	75.0	2.6
8	8.0	.3	42	42.0	1.5	76	76.0	2.6
9	9.0	.3	43	43.0	1.5	77	77.0	2.7
10	10.0	.3	44	44.0	1.5	78	78.0	2.7
11	11.0	.4	45	45.0	1.6	79	79.0	2.8
12	12.0	.4	46	46.0	1.6	80	80.0	2.8
13	13.0	.4	47	47.0	1.6	81	80.9	2.8
14	14.0	.5	48	48.0	1.7	82	81.9	2.9
15	15.0	.5	49	49.0	1.7	83	82.9	2.9
16	16.0	.6	50	50.0	1.7	84	83.9	2.9
17	17.0	.6	51	51.0	1.8	85	84.9	3.0
18	18.0	.6	52	52.0	1.8	86	85.9	3.0
19	19.0	.7	53	53.0	1.8	87	86.9	3.0
20	20.0	.7	54	54.0	1.9	88	87.9	3.1
21	21.0	.7	55	55.0	1.9	89	88.9	3.1
22	22.0	.8	56	56.0	1.9	90	89.9	3.1
23	23.0	.8	57	57.0	2.0	91	90.9	3.2
24	24.0	.8	58	58.0	2.0	92	91.9	3.2
25	25.0	.9	59	59.0	2.0	93	92.9	3.2
26	26.0	.9	60	60.0	2.1	94	93.9	3.3
27	27.0	.9	61	61.0	2.1	95	94.9	3.3
28	28.0	1.0	62	62.0	2.2	96	95.9	3.4
29	29.0	1.0	63	63.0	2.2	97	96.9	3.4
30	30.0	1.0	64	64.0	2.2	98	97.9	3.4
31	31.0	1.1	65	65.0	2.3	99	98.9	3.5
32	32.0	1.1	66	66.0	2.3	100	99.9	3.5
33	33.0	1.1	67	67.0	2.3	200	199.8	7.0
34	34.0	1.2	68	68.0	2.4	300	299.7	10.5
Dif.	Dep.	Lat.	Dif.	Dep.	Lat.	Dif.	Dep.	Lat.
	88 Deg.			88 Deg.			88 Deg.	



Dif.	3 Deg.		Dif.	3 Deg.		Dif.	3 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	1.0	.1	35	35.0	1.8	69	68.9	3.6
2	2.0	.1	36	36.0	1.9	70	69.9	3.7
3	3.0	.1	37	37.0	1.9	71	70.9	3.7
4	4.0	.2	38	38.0	2.0	72	71.9	3.8
5	5.0	.2	39	39.0	2.0	73	72.9	3.8
6	6.0	.3	40	40.0	2.1	74	73.9	3.9
7	7.0	.4	41	41.0	2.1	75	74.9	3.9
8	8.0	.4	42	42.0	2.2	76	75.9	4.0
9	9.0	.5	43	43.0	2.2	77	76.9	4.0
10	10.0	.5	44	44.0	2.3	78	77.9	4.1
11	11.0	.6	45	45.0	2.3	79	78.9	4.1
12	12.0	.6	46	46.0	2.4	80	79.9	4.2
13	13.0	.7	47	47.0	2.4	81	80.9	4.2
14	14.0	.7	48	48.0	2.5	82	81.9	4.3
15	15.0	.8	49	49.0	2.6	83	82.9	4.3
16	16.0	.8	50	50.0	2.6	84	83.9	4.4
17	17.0	.9	51	50.9	2.7	85	84.9	4.4
18	18.0	.9	52	51.9	2.7	86	85.9	4.5
19	19.0	1.0	53	52.9	2.8	87	86.9	4.5
20	20.0	1.0	54	53.9	2.8	88	87.9	4.6
21	21.0	1.1	55	54.9	2.9	89	88.9	4.6
22	22.0	1.1	56	55.9	2.9	90	89.9	4.7
23	23.0	1.2	57	56.9	3.0	91	90.9	4.8
24	24.0	1.2	58	57.9	3.0	92	91.9	4.8
25	25.0	1.3	59	58.9	3.1	93	92.9	4.9
26	26.0	1.3	60	59.9	3.1	94	93.9	4.9
27	27.0	1.4	61	60.9	3.2	95	94.9	5.0
28	28.0	1.5	62	61.9	3.2	96	95.9	5.0
29	29.0	1.5	63	62.9	3.3	97	96.9	5.1
30	30.0	1.6	64	63.9	3.3	98	97.9	5.1
31	31.0	1.6	65	64.9	3.4	99	98.9	5.2
32	32.0	1.7	66	65.9	3.5	100	99.9	5.2
33	33.0	1.7	67	66.9	3.5	200	199.7	10.5
34	34.0	1.8	68	67.9	3.6	300	299.6	15.7
Dif.	Dep.	Lat.	Dif.	Dep.	Lat.	Dif.	Dep.	Lat.
	87 Deg.			87 Deg.			87 Deg.	



Diff.	4 Deg.		Diff.	4 Deg.		Diff.	4 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	1.0	.1	35	34.9	2.5	69	68.8	4.8
2	2.0	.1	36	35.9	2.5	70	69.8	4.9
3	3.0	.2	37	36.9	2.6	71	60.8	4.0
4	4.0	.3	38	37.9	2.7	72	71.8	5.0
5	5.0	.3	39	38.9	2.7	73	72.8	5.1
6	6.0	.4	40	39.9	2.8	74	73.8	5.2
7	7.0	.5	41	40.9	2.9	75	74.8	5.2
8	8.0	.6	42	41.9	2.9	76	75.8	5.3
9	9.0	.6	43	42.9	3.0	77	76.8	5.4
10	10.0	.7	44	43.9	3.1	78	77.8	5.5
11	11.0	.8	45	44.9	3.1	79	78.8	5.5
12	12.0	.8	46	45.9	3.2	80	79.8	5.6
13	13.0	.9	47	46.9	3.3	81	80.8	5.7
14	14.0	1.0	48	47.9	3.4	82	81.8	5.7
15	15.0	1.0	49	48.9	3.4	83	82.8	5.8
16	16.0	1.1	50	49.9	3.5	84	83.8	5.9
17	17.0	1.2	51	50.9	3.6	85	84.8	5.9
18	18.0	1.3	52	51.9	3.6	86	85.8	6.0
19	19.0	1.3	53	52.9	3.7	87	86.8	6.1
20	20.0	1.4	54	53.9	3.8	88	87.8	6.1
21	20.9	1.5	55	54.9	3.8	89	88.8	6.3
22	21.9	1.5	56	55.9	3.9	90	89.8	6.3
23	22.9	1.6	57	56.9	4.0	91	90.8	6.4
24	23.9	1.7	58	57.9	4.0	92	91.8	6.5
25	24.9	1.7	59	58.9	4.1	93	92.8	6.5
26	25.9	1.8	60	59.9	4.2	94	93.8	6.6
27	26.9	1.9	61	60.9	4.3	95	94.8	6.6
28	27.9	2.0	62	61.9	4.3	96	95.8	6.7
29	28.9	2.0	63	62.9	4.4	97	96.8	6.8
30	29.9	2.1	64	63.9	4.5	98	97.8	6.8
31	20.9	2.2	65	64.8	4.5	99	98.8	6.9
32	21.9	2.2	66	65.8	4.6	100	99.8	7.0
33	22.9	2.3	67	66.8	4.7	200	199.5	14.0
34	23.9	2.4	68	67.8	4.8	300	299.3	20.9
Diff.	Dep.	Lat.	Diff.	Dep.	Lat.	Diff.	Dep.	Lat.
	86 Deg.			86 Deg.			86 Deg.	



Dift.	5 Deg.		Dift.	5 Deg.		Dift.	85 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	1.0	.1	35	34.9	3.0	69	68.7	6.0
2	2.0	.2	36	35.9	3.1	70	69.7	6.1
3	3.0	.3	37	36.9	3.2	71	70.7	6.2
4	4.0	.3	38	37.9	3.3	72	71.7	6.3
5	5.0	.4	39	38.8	3.4	73	72.7	6.4
6	6.0	.5	40	39.8	3.5	74	73.7	6.5
7	7.0	.6	41	40.8	3.6	75	74.7	6.5
8	8.0	.7	42	41.8	3.7	76	75.7	6.6
9	9.0	.8	43	42.8	3.7	77	76.7	6.7
10	10.0	.9	44	43.8	3.8	78	77.7	6.8
11	11.0	1.0	45	44.8	3.9	79	78.7	6.9
12	12.0	1.0	46	45.8	4.0	80	79.7	7.0
13	13.0	1.1	47	46.8	4.1	81	80.7	7.1
14	14.0	1.2	48	47.8	4.2	82	81.7	7.1
15	15.0	1.3	49	48.8	4.3	83	82.7	7.2
16	15.9	1.4	50	49.8	4.4	84	83.7	7.3
17	16.9	1.5	51	50.8	4.5	85	84.7	7.4
18	17.9	1.6	52	51.8	4.5	86	85.7	7.5
19	18.9	1.7	53	52.8	4.6	87	86.7	7.6
20	19.9	1.7	54	53.8	4.7	88	87.7	7.7
21	20.9	1.8	55	54.8	4.8	89	88.7	7.8
22	21.9	1.9	56	55.8	4.9	90	89.7	7.8
23	22.9	2.0	57	56.8	5.0	91	90.7	7.9
24	23.9	2.1	58	57.8	5.1	92	91.6	8.0
25	24.6	2.2	59	58.8	5.2	93	92.6	8.1
26	25.9	2.3	60	59.8	5.2	94	93.6	8.2
27	26.9	2.4	61	60.8	5.3	95	94.6	8.3
28	27.9	2.4	62	61.8	5.4	96	95.6	8.4
29	28.9	2.5	63	62.8	5.5	97	96.6	8.4
30	29.9	2.6	64	63.8	5.6	98	97.6	8.5
31	30.9	2.7	65	64.8	5.7	99	98.6	8.6
32	31.9	2.8	66	65.8	5.8	100	99.7	8.7
33	32.9	2.9	67	66.8	5.8	200	199.2	17.4
34	33.9	3.0	68	67.7	5.9	300	298.9	26.2
Dift.	Dep.	Lat.	Dift.	Dep.	Lat.	Dift.	Dep.	Lat.
	85 Deg.			85 Deg.			85 Deg.	



Diff.	6 Deg.		Diff.	6 Deg.		Diff.	6 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	1.0	.1	35	34.8	3.6	69	68.6	7.2
2	2.0	.2	36	35.8	3.8	70	69.6	7.3
3	3.0	.3	37	36.8	3.9	71	70.6	7.4
4	4.0	.4	38	37.8	4.0	72	71.6	7.5
5	5.0	.5	39	38.8	4.1	73	72.6	7.6
6	6.0	.6	40	39.8	4.2	74	73.6	7.7
7	7.0	.7	41	40.8	4.3	75	74.6	7.8
8	8.0	.8	42	41.8	4.4	76	75.6	7.9
9	8.9	.9	43	42.8	4.5	77	76.6	8.0
10	9.9	1.0	44	43.8	4.6	78	77.6	8.1
11	10.9	1.1	45	44.7	4.7	79	78.6	8.2
12	11.9	1.2	46	45.7	4.8	80	79.6	8.3
13	12.9	1.4	47	46.7	4.9	81	80.6	8.5
14	13.9	1.5	48	47.7	5.0	82	81.5	8.6
15	14.9	1.6	49	48.7	5.1	83	82.5	8.7
16	15.9	1.7	50	49.7	5.2	84	83.5	8.8
17	16.9	1.8	51	50.7	5.3	85	84.5	8.9
18	17.9	1.9	52	51.7	5.4	86	85.5	9.0
19	18.9	2.0	53	52.7	5.5	87	86.5	9.1
20	19.9	2.1	54	53.7	5.6	88	87.5	9.2
21	20.9	2.2	55	54.7	5.7	89	88.5	9.3
22	21.9	2.3	56	55.7	5.8	90	89.5	9.4
23	22.9	2.4	57	56.7	5.9	91	90.5	9.5
24	23.9	2.5	58	57.7	6.1	92	91.5	9.6
25	24.9	2.6	59	58.7	6.2	93	92.5	9.7
26	25.9	2.7	60	59.7	6.3	94	93.5	9.8
27	26.8	2.8	61	60.7	6.4	95	94.5	9.9
28	27.8	2.9	62	61.7	6.5	96	95.5	10.0
29	28.8	3.0	63	62.7	6.6	97	96.5	10.1
30	29.8	3.1	64	63.7	6.7	98	97.5	10.2
31	30.8	3.2	65	64.6	6.8	99	98.5	10.3
32	31.8	3.3	66	65.6	6.9	100	99.5	10.4
33	32.8	3.4	67	66.6	7.0	200	198.9	20.9
34	33.8	3.5	68	67.6	7.1	300	298.3	31.3
Diff.	Dep.	Lat.	Diff.	Dep.	Lat.	Diff.	Dep.	Lat.
	84 Deg.			84 Deg.			84 Deg.	



Diff.	7 Deg.		Diff.	7 Deg.		Diff.	7 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	1.0	.1	35	34.7	4.3	69	68.5	8.4
2	2.0	.2	36	35.7	4.4	70	69.5	8.5
3	3.0	.4	37	36.7	4.5	71	70.5	8.7
4	4.0	.5	38	37.7	4.6	72	71.5	8.8
5	5.0	.6	39	38.7	4.8	73	72.5	8.9
6	6.0	.7	40	39.7	4.9	74	73.4	9.0
7	6.9	.8	41	40.7	5.0	75	74.4	9.2
8	7.9	1.0	42	41.7	5.1	76	75.4	9.3
9	8.9	1.1	43	42.7	5.2	77	76.4	9.4
10	9.9	1.2	44	43.7	5.4	78	77.4	9.5
11	10.9	1.3	45	44.7	5.5	79	78.4	9.6
12	11.9	1.5	46	45.6	5.6	80	79.4	9.8
13	12.9	1.6	47	46.6	5.7	81	80.4	9.9
14	13.9	1.7	48	47.6	5.9	82	81.4	10.0
15	14.9	1.8	49	48.6	6.0	83	82.4	10.1
16	15.9	2.0	50	49.6	6.1	84	83.4	10.3
17	16.9	2.1	51	50.6	6.2	85	84.4	10.4
18	17.9	2.2	52	51.6	6.3	86	85.4	10.5
19	18.9	2.3	53	52.6	6.5	87	86.3	10.6
20	19.9	2.4	54	53.6	6.6	88	87.3	10.7
21	20.8	2.6	55	54.6	6.7	89	88.3	10.9
22	21.8	2.7	56	55.6	6.8	90	89.3	11.0
23	22.8	2.8	57	56.6	6.9	91	90.3	11.1
24	23.8	2.9	58	57.6	7.1	92	91.3	11.2
25	24.8	3.0	59	58.6	7.2	93	92.3	11.3
26	25.8	3.2	60	59.6	7.3	94	93.3	11.5
27	26.8	3.3	61	60.5	7.4	95	94.3	11.6
28	27.8	3.4	62	61.5	7.6	96	95.3	11.7
29	28.8	3.5	63	62.5	7.7	97	96.3	11.8
30	29.8	3.7	64	63.5	7.8	98	97.3	12.0
31	30.8	3.8	65	64.5	7.9	99	98.3	12.1
32	31.8	3.9	66	65.5	8.1	100	99.3	12.2
33	32.7	4.0	67	66.5	8.2	200	198.5	24.4
34	33.7	4.1	68	67.5	8.3	300	297.8	36.6
Diff.	Dep.	Lat.	Diff.	Dep.	Lat.	Diff.	Dep.	Lat.
	83 Deg.			83 Deg.			83 Deg.	



Dif.	8 Deg.		Dif.	8 Deg.		Dif.	8 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	1.0	.1	35	34.7	4.9	69	68.3	9.6
2	2.0	.3	36	35.7	5.0	70	69.3	9.7
3	3.0	.4	37	36.6	5.1	71	70.3	9.9
4	4.0	.6	38	37.6	5.3	72	71.3	10.0
5	5.0	.7	39	38.6	5.4	73	72.3	10.2
6	5.9	.8	40	39.6	5.6	74	73.3	10.3
7	6.9	1.0	41	40.6	5.7	75	74.3	10.4
8	7.9	1.1	42	41.6	5.8	76	75.3	10.6
9	8.9	1.3	43	42.6	6.0	77	76.3	10.7
10	9.9	1.4	44	43.6	6.1	78	77.2	10.9
11	10.9	1.5	45	44.6	6.3	79	78.2	11.0
12	11.9	1.7	46	45.6	6.4	80	79.2	11.1
13	12.9	1.8	47	46.5	6.5	81	80.2	11.3
14	13.9	1.9	48	47.5	6.7	82	81.2	11.4
15	14.8	2.1	49	48.5	6.8	83	82.2	11.5
16	15.8	2.2	50	49.5	7.0	84	83.2	11.7
17	16.8	2.4	51	50.5	7.1	85	84.2	11.8
18	17.8	2.5	52	51.5	7.2	86	85.2	12.0
19	18.8	2.6	53	52.5	7.4	87	86.2	12.1
20	19.8	2.8	54	53.5	7.5	88	87.2	12.2
21	20.8	2.9	55	54.5	7.7	89	88.1	12.4
22	21.8	3.1	56	55.5	7.8	90	89.1	12.5
23	22.8	3.2	57	56.5	7.9	91	90.1	12.7
24	23.8	3.3	58	57.4	8.1	92	91.1	12.8
25	24.8	3.5	59	58.4	8.2	93	92.1	12.9
26	25.7	3.6	60	59.4	8.3	94	93.1	13.1
27	26.7	3.8	61	60.4	8.5	95	94.1	13.2
28	27.7	3.9	62	61.4	8.6	96	95.1	13.4
29	28.7	4.0	63	62.4	8.8	97	96.1	13.5
30	29.7	4.2	64	63.4	8.9	98	97.0	13.6
31	30.7	4.3	65	64.4	9.0	99	98.0	13.8
32	31.7	4.4	66	65.4	9.2	100	99.0	13.9
33	32.7	4.6	67	66.4	9.3	200	198.1	27.8
34	33.7	4.7	68	67.3	9.5	300	297.1	41.8
Dif.	Dep.	Lat.	Dif.	Dep.	Lat.	Dif.	Dep.	Lat.
	82 Deg.			82 Deg.			82 Deg.	



Dif.	9 Deg.		Dif.	9 Deg.		Dif.	9 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	1.0	.2	35	34.6	5.5	69	68.2	10.8
2	2.0	.3	36	35.6	5.6	70	69.1	10.9
3	3.0	.5	37	36.6	5.8	71	70.1	11.1
4	4.0	.6	38	37.5	5.9	72	71.1	11.2
5	4.9	.8	39	38.5	6.1	73	72.1	11.4
6	5.9	.9	40	39.5	6.3	74	73.1	11.6
7	6.9	1.1	41	40.5	6.4	75	74.1	11.7
8	7.9	1.3	42	41.5	6.6	76	75.1	11.9
9	8.9	1.4	43	42.5	6.7	77	76.1	12.0
10	9.9	1.6	44	43.5	6.9	78	77.0	12.2
11	10.9	1.7	45	44.5	7.0	79	78.0	12.4
12	11.9	1.9	46	45.4	7.2	80	79.0	12.5
13	12.9	2.0	47	46.4	7.3	81	80.0	12.7
14	13.8	2.2	48	47.4	7.5	82	81.0	12.8
15	14.8	2.3	49	48.4	7.7	83	82.0	13.0
16	15.8	2.5	50	49.4	7.8	84	83.0	13.1
17	16.8	2.6	51	50.4	8.0	85	84.0	13.3
18	17.8	2.8	52	51.4	8.1	86	85.0	13.4
19	18.8	3.0	53	52.4	8.3	87	85.9	13.6
20	19.8	3.1	54	53.4	8.4	88	86.9	13.8
21	20.8	3.3	55	54.3	8.6	89	87.9	13.9
22	21.7	3.4	56	55.3	8.8	90	88.9	14.1
23	22.7	3.6	57	56.3	8.9	91	89.9	14.2
24	23.7	3.7	58	57.3	9.1	92	90.9	14.4
25	24.7	3.9	59	58.3	9.2	93	91.9	14.5
26	25.7	4.1	60	59.3	9.4	94	92.9	14.7
27	26.7	4.2	61	60.3	9.5	95	93.8	14.8
28	27.7	4.4	62	61.2	9.7	96	94.8	15.0
29	28.7	4.5	63	62.2	9.8	97	95.8	15.2
30	29.6	4.7	64	63.2	10.0	98	96.8	15.3
31	30.6	4.8	65	64.2	10.2	99	97.8	15.5
32	31.6	5.0	66	65.2	10.3	100	98.8	15.6
33	32.6	5.1	67	66.2	10.5	200	197.5	31.3
34	33.6	5.3	68	67.2	10.6	300	296.3	46.9
Dif.	Dep.	Lat.	Dif.	Dep.	Lat.	Dif.	Dep.	Lat.
	81 Deg.			81 Deg.			81 Deg.	



Diff.	10 Deg.		Diff.	10 Deg.		Diff.	10 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	1.0	.2	35	34.5	6.1	69	68.0	12.0
2	2.0	.3	36	35.5	6.2	70	68.9	12.1
3	3.0	.5	37	36.5	6.4	71	69.9	12.3
4	3.9	.7	38	37.4	6.6	72	70.9	12.5
5	4.9	.9	39	38.4	6.8	73	71.9	12.7
6	5.9	1.0	40	39.4	6.9	74	72.9	12.8
7	6.9	1.2	41	40.4	7.1	75	73.9	13.0
8	7.9	1.4	42	41.4	7.3	76	74.9	13.2
9	8.9	1.6	43	42.4	7.5	77	75.8	13.3
10	9.9	1.7	44	43.3	7.6	78	76.8	13.5
11	10.8	1.9	45	44.3	7.8	79	77.8	13.7
12	11.8	2.1	46	45.3	8.0	80	78.8	13.9
13	12.8	2.3	47	46.3	8.1	81	79.8	14.1
14	13.8	2.4	48	47.3	8.3	82	80.8	14.2
15	14.8	2.6	49	48.3	8.7	83	81.7	14.4
16	15.8	2.8	50	49.2	8.5	84	82.7	14.6
17	16.8	3.0	51	50.2	8.8	85	83.7	14.8
18	17.7	3.1	52	51.2	9.0	86	84.7	14.9
19	18.7	3.3	53	52.2	9.2	87	85.7	15.1
20	19.7	3.5	54	53.2	9.4	88	86.7	15.3
21	20.7	3.6	55	54.2	9.5	89	87.6	15.4
22	21.7	3.8	56	55.2	9.7	90	88.6	15.6
23	22.7	4.0	57	56.1	9.9	91	89.6	15.8
24	23.6	4.2	58	57.1	10.1	92	90.6	16.0
25	24.6	4.3	59	58.1	10.2	93	91.6	16.1
26	25.6	4.5	60	59.1	10.4	94	92.6	16.3
27	26.6	4.7	61	60.1	10.6	95	93.6	16.5
28	27.6	4.9	62	61.1	10.8	96	94.6	16.7
29	28.6	5.0	63	62.0	10.9	97	95.5	16.8
30	29.6	5.2	64	63.0	11.1	98	96.5	17.0
31	30.5	5.4	65	64.0	11.3	99	97.5	17.2
32	31.5	5.5	66	65.0	11.5	100	98.5	17.4
33	32.5	5.7	67	66.0	11.6	200	197.0	34.7
34	33.5	5.9	68	67.0	11.8	300	295.4	52.1
Diff.	Dep.	Lat.	Diff.	Dep.	Lat.	Diff.	Dep.	Lat.
	80 Deg.			80 Deg.			80 Deg.	



Diff.	11 Deg.		Diff.	11 Deg.		Diff.	11 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	1.0	.2	35	34.3	6.7	69	67.7	13.2
2	2.0	.4	36	35.3	6.9	70	68.7	13.4
3	2.9	.6	37	36.3	7.1	71	69.7	13.5
4	3.9	.8	38	37.3	7.2	72	70.7	13.7
5	4.9	.9	39	38.3	7.4	73	71.6	13.9
6	5.9	1.1	40	39.3	7.6	74	72.6	14.1
7	6.9	1.3	41	40.2	7.8	75	73.6	14.3
8	7.8	1.5	42	41.2	8.0	76	74.6	14.5
9	8.8	1.7	43	42.2	8.2	77	75.6	14.7
10	9.8	1.9	44	43.2	8.4	78	76.5	14.9
11	10.8	2.1	45	44.2	8.6	79	77.5	15.1
12	11.8	2.3	46	45.2	8.8	80	78.5	15.3
13	12.8	2.5	47	46.1	9.0	81	79.5	15.4
14	13.7	2.7	48	47.1	9.2	82	80.5	15.6
15	14.7	2.9	49	48.1	9.3	83	81.5	15.8
16	15.7	3.0	50	49.1	9.5	84	82.4	16.0
17	16.7	3.2	51	50.1	9.7	85	83.4	16.2
18	17.7	3.4	52	51.0	9.9	86	84.4	16.4
19	18.6	3.6	53	52.0	10.1	87	85.4	16.6
20	19.6	3.8	54	53.0	10.3	88	86.4	16.8
21	20.6	4.0	55	54.0	10.5	89	87.3	17.0
22	21.6	4.2	56	55.0	10.7	90	88.3	17.2
23	22.6	4.4	57	55.9	10.9	91	89.3	17.4
24	23.6	4.6	58	56.9	11.1	92	90.3	17.6
25	24.5	4.8	59	57.9	11.2	93	91.3	17.7
26	25.5	5.0	60	58.9	11.4	94	92.3	17.9
27	26.5	5.1	61	59.9	11.6	95	93.2	18.1
28	27.5	5.3	62	60.9	11.8	96	94.2	18.3
29	28.5	5.5	63	61.8	12.0	97	95.2	18.5
30	29.4	5.7	64	62.8	12.2	98	96.2	18.7
31	30.4	5.9	65	63.8	12.4	99	97.2	18.9
32	31.4	6.1	66	64.8	12.6	100	98.1	19.1
33	32.4	6.3	67	65.8	12.8	200	196.3	38.2
34	33.4	6.5	68	66.8	13.0	300	294.4	57.2
Diff.	Dep.	Lat.	Diff.	Dep.	Lat.	Diff.	Dep.	Lat.
	79 Deg.			79 Deg.			79 Deg.	



Dif.	12 Deg.		Dif.	12 Deg.		Dif.	12 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	1.0	.2	35	34.2	7.3	69	67.5	14.4
2	2.0	.4	36	35.2	7.5	70	68.5	14.6
3	2.9	.6	37	36.2	7.7	71	69.4	14.8
4	3.9	.8	38	37.2	7.9	72	60.4	15.0
5	4.9	1.0	39	38.1	8.1	73	71.4	15.2
6	5.9	1.2	40	39.1	8.3	74	72.4	15.4
7	6.8	1.5	41	40.1	8.5	75	73.4	15.6
8	7.8	1.7	42	41.1	8.7	76	74.3	15.8
9	8.8	1.9	43	42.0	9.0	77	75.3	16.0
10	9.8	2.1	44	43.0	9.2	78	76.3	16.2
11	10.8	2.3	45	44.0	9.4	79	77.3	16.4
12	11.7	2.5	46	45.0	9.6	80	78.3	16.6
13	12.7	2.7	47	46.0	9.8	81	79.2	16.8
14	13.7	2.9	48	47.0	10.0	82	80.2	17.0
15	14.7	3.1	49	47.9	10.2	83	81.2	17.3
16	15.6	3.3	50	48.9	10.4	84	82.2	17.5
17	16.6	3.6	51	49.9	10.6	85	83.1	17.7
18	17.6	3.8	52	50.9	10.8	86	84.1	17.9
19	18.6	4.0	53	51.8	11.0	87	85.1	18.1
20	19.6	4.2	54	52.8	11.2	88	86.1	18.3
21	20.5	4.4	55	53.8	11.4	89	87.1	18.5
22	21.5	4.6	56	54.8	11.6	90	88.0	18.7
23	22.5	4.8	57	55.8	11.8	91	89.0	18.9
24	23.5	5.0	58	56.7	12.1	92	90.0	19.1
25	24.5	5.2	59	57.7	12.3	93	91.0	19.3
26	25.4	5.4	60	58.7	12.5	94	92.0	19.5
27	26.4	5.6	61	59.7	12.7	95	92.9	19.7
28	27.4	5.8	62	60.7	12.9	96	93.9	20.0
29	28.4	6.0	63	61.6	13.1	97	94.9	20.2
30	29.3	6.2	64	62.6	13.3	98	95.9	20.4
31	30.3	6.4	65	63.6	13.5	99	96.8	20.6
32	31.3	6.6	66	64.6	13.7	100	97.8	20.8
33	32.3	6.9	67	65.5	14.0	200	195.6	41.6
34	33.3	7.1	68	66.5	14.2	300	293.4	62.4
Dif.	Dep.	Lat.	Dif.	Dep.	Lat.	Dif.	Dep.	Lat.
	78 Deg.			78 Deg.			78 Deg.	



Diff.	13 Deg.		Diff.	13 Deg.		Diff.	13 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	1.0	.2	35	34.1	7.9	69	67.2	15.5
2	2.0	.4	36	35.1	8.1	70	68.2	15.7
3	2.9	.7	37	36.1	8.3	71	69.2	16.0
4	3.9	.9	38	37.0	8.6	72	70.2	16.2
5	4.9	1.1	39	38.0	8.8	73	71.1	16.4
6	5.9	1.3	40	39.0	9.0	74	72.1	16.6
7	6.8	1.6	41	40.0	9.2	75	73.1	16.9
8	7.8	1.8	42	40.9	9.4	76	74.1	17.1
9	8.8	2.0	43	41.9	9.7	77	75.0	17.3
10	9.8	2.2	44	42.9	9.9	78	76.0	17.5
11	10.7	2.5	45	43.8	10.1	79	77.0	17.8
12	11.7	2.7	46	44.8	10.3	80	78.0	18.0
13	12.7	2.9	47	45.8	10.6	81	78.9	18.2
14	13.6	3.1	48	46.8	10.8	82	79.9	18.4
15	14.6	3.4	49	47.7	11.0	83	80.9	18.7
16	15.6	3.6	50	48.7	11.2	84	81.8	18.9
17	16.6	3.8	51	49.7	11.5	85	82.8	19.1
18	17.6	4.0	52	50.7	11.7	86	83.8	19.3
19	18.5	4.3	53	51.6	11.9	87	84.8	19.6
20	19.5	4.5	54	52.6	12.1	88	85.7	19.8
21	20.5	4.7	55	53.6	12.4	89	86.7	20.0
22	21.5	4.9	56	54.6	12.6	90	87.7	20.2
23	22.4	5.2	57	55.5	12.8	91	88.7	20.5
24	23.4	5.4	58	56.5	13.0	92	89.6	20.7
25	24.4	5.6	59	57.5	13.3	93	90.6	20.9
26	25.4	5.8	60	58.5	13.5	94	91.6	21.1
27	26.3	6.1	61	59.4	13.7	95	92.6	21.4
28	27.3	6.3	62	60.4	14.0	96	93.5	21.6
29	28.3	6.5	63	61.4	14.2	97	94.5	21.8
30	29.2	6.7	64	62.4	14.4	98	95.5	22.1
31	30.2	7.0	65	63.4	14.6	99	96.5	22.3
32	31.2	7.2	66	64.3	14.8	100	97.4	22.5
33	32.2	7.4	67	65.3	15.1	200	194.9	45.0
34	33.1	7.6	68	66.3	15.3	300	292.3	67.5
Diff.	Dep.	Lat.	Diff.	Dep.	Lat.	Diff.	Dep.	Lat.
	77 Deg.			77 Deg.			77 Deg.	



Dif.	14 Deg.		Dif.	14 Deg.		Dif.	14 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	1.0	.2	35	34.0	8.5	69	66.9	16.7
2	1.9	.5	36	34.9	8.7	70	67.9	16.9
3	2.9	.7	37	35.9	9.0	71	68.9	17.2
4	3.9	1.0	38	36.9	9.2	72	69.8	17.4
5	4.8	1.2	39	37.8	9.4	73	70.8	17.7
6	5.8	1.4	40	38.8	9.7	74	71.8	17.9
7	6.8	1.7	41	39.8	9.9	75	72.8	18.2
8	7.8	1.9	42	40.7	10.2	76	73.7	18.4
9	8.7	2.2	43	41.7	10.4	77	74.7	18.7
10	9.7	2.4	44	42.7	10.7	78	75.7	18.9
11	10.7	2.7	45	43.7	10.9	79	76.6	19.1
12	11.6	2.9	46	44.6	11.1	80	77.6	19.4
13	12.6	3.1	47	45.6	11.4	81	78.6	19.5
14	13.6	3.4	48	46.6	11.6	82	79.6	19.7
15	14.6	3.6	49	47.5	11.9	83	80.5	20.0
16	15.5	3.9	50	48.5	12.1	84	81.5	20.2
17	16.5	4.1	51	49.5	12.3	85	82.5	20.5
18	17.5	4.4	52	50.4	12.6	86	83.4	20.7
19	18.4	4.6	53	51.4	12.8	87	84.4	20.9
20	19.4	4.8	54	52.4	13.1	88	85.4	21.3
21	20.4	5.1	55	53.4	13.3	89	86.4	21.5
22	21.3	5.3	56	54.3	13.6	90	87.3	21.8
23	22.3	5.6	57	55.3	13.8	91	88.3	22.0
24	23.3	5.8	58	56.3	14.0	92	89.3	22.3
25	24.2	6.0	59	57.2	14.3	93	90.2	22.5
26	25.2	6.3	60	58.2	14.5	94	91.2	22.7
27	26.2	6.5	61	59.2	14.8	95	92.1	23.0
28	27.2	6.8	62	60.1	15.0	96	93.1	23.2
29	28.1	7.0	63	61.1	15.3	97	94.1	23.5
30	29.1	7.3	64	62.1	15.5	98	95.1	23.7
31	30.1	7.5	65	63.1	15.7	99	96.0	24.0
32	31.0	7.7	66	64.0	16.0	100	97.0	24.2
33	32.0	8.0	67	65.0	16.2	200	194.1	48.4
34	33.0	8.2	68	66.0	16.5	300	291.1	72.5
Dif.	Dep.	Lat.	Dif.	Dep.	Lat.	Dif.	Dep.	Lat.
	76 Deg.			76 Deg.			76 Deg.	



Diff.	15 Deg.	
	Lat.	Dep.
1	1.0	.3
2	1.9	.5
3	2.9	.8
4	3.9	1.0
5	4.8	1.3
6	5.8	1.6
7	6.8	1.8
8	7.7	2.1
9	8.7	2.3
10	9.7	2.6
11	10.6	2.8
12	11.6	3.1
13	12.6	3.4
14	13.5	3.6
15	14.5	3.9
16	15.5	4.1
17	16.4	4.4
18	17.4	4.7
19	18.3	4.9
20	19.3	5.2
21	20.3	5.4
22	21.3	5.7
23	22.2	6.0
24	23.2	6.2
25	24.2	6.5
26	25.1	6.7
27	26.1	7.0
28	27.1	7.3
29	28.0	7.5
30	29.0	7.8
31	29.9	8.0
32	30.9	8.3
33	31.9	8.5
34	32.8	8.8
Diff.	Dep.	Lat.
	75	Deg.

Diff.	15 Deg.	
	Lat.	Dep.
35	33.8	9.1
36	34.8	9.3
37	35.7	9.6
38	36.7	9.8
39	37.7	10.1
40	38.6	10.3
41	39.6	10.6
42	40.6	10.9
43	41.5	11.1
44	42.5	11.4
45	43.5	11.6
46	44.4	11.9
47	45.4	12.3
48	46.4	12.5
49	47.3	12.8
50	48.3	12.9
51	49.3	13.2
52	50.2	13.5
53	51.2	13.7
54	52.2	14.0
55	53.1	14.2
56	54.1	14.5
57	55.1	14.8
58	56.0	15.0
59	57.0	15.3
60	58.0	15.5
61	58.9	15.8
62	59.9	16.0
63	60.8	16.3
64	61.8	16.6
65	62.8	16.8
66	63.8	17.1
67	64.7	17.4
68	65.7	17.6
Diff.	Dep.	Lat.
	75	Deg.

Diff.	15 Deg.	
	Lat.	Dep.
69	66.6	17.9
70	67.6	18.1
71	68.6	18.4
72	69.6	18.6
73	70.5	18.9
74	71.5	19.2
75	72.4	19.4
76	73.4	19.7
77	74.4	20.0
78	75.4	20.2
79	76.3	20.5
80	77.3	20.7
81	78.3	21.0
82	79.2	21.2
83	80.2	21.5
84	81.1	21.7
85	82.1	22.0
86	83.1	22.3
87	84.0	22.5
88	85.0	22.8
89	86.0	23.0
90	86.9	23.3
91	87.9	23.6
92	88.9	23.8
93	89.8	24.1
94	90.8	24.3
95	91.8	24.6
96	92.7	24.8
97	93.7	25.1
98	94.7	25.4
99	95.6	25.6
100	96.6	25.9
200	193.2	51.8
300	289.8	77.6
Diff.	Dep.	Lat.
	75	Deg.



Diff.	16 Deg.		Diff.	16 Deg.		Diff.	16 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	1.0	.3	35	33.6	9.7	69	66.3	19.0
2	1.9	.6	36	34.6	9.9	70	67.3	19.3
3	2.9	.8	37	35.6	10.2	71	68.2	19.6
4	3.8	1.1	38	36.5	10.5	72	69.2	19.9
5	4.8	1.4	39	37.5	10.7	73	70.2	20.1
6	5.8	1.7	40	38.4	11.0	74	71.1	20.4
7	6.7	1.9	41	39.4	11.3	75	72.1	20.7
8	7.7	2.2	42	40.4	11.6	76	73.1	21.0
9	8.6	2.5	43	41.3	11.9	77	74.0	21.3
10	9.6	2.8	44	42.3	12.1	78	75.0	21.5
11	10.6	3.0	45	43.2	12.4	79	75.9	21.8
12	11.5	3.3	46	44.2	12.7	80	76.9	22.0
13	12.5	3.6	47	45.2	13.0	81	77.9	22.3
14	13.4	3.9	48	46.1	13.2	82	78.8	22.6
15	14.4	4.1	49	47.1	13.5	83	79.8	22.9
16	15.4	4.4	50	48.1	13.8	84	80.7	23.2
17	16.3	4.7	51	49.0	14.1	85	81.7	23.5
18	17.3	5.0	52	50.0	14.3	86	82.7	23.7
19	18.3	5.3	53	50.9	14.6	87	83.6	24.0
20	19.2	5.5	54	51.9	14.9	88	84.6	24.3
21	20.2	5.8	55	52.9	15.1	89	85.6	24.5
22	21.1	6.1	56	53.8	15.4	90	86.5	24.8
23	22.1	6.3	57	54.8	15.7	91	87.5	25.1
24	23.1	6.6	58	55.7	16.0	92	88.4	25.4
25	24.0	6.9	59	56.7	16.3	93	89.4	25.7
26	25.0	7.2	60	57.7	16.5	94	90.4	25.9
27	25.9	7.5	61	58.6	16.8	95	91.3	26.2
28	26.9	7.7	62	59.6	17.1	96	92.3	26.5
29	27.9	8.0	63	60.6	17.4	97	93.2	26.7
30	28.8	8.3	64	61.5	17.7	98	94.2	27.0
31	29.8	8.5	65	62.5	17.9	99	95.2	27.3
32	30.8	8.8	66	63.4	18.2	100	96.1	27.6
33	31.7	9.1	67	64.4	18.5	200	192.3	55.1
34	32.7	9.4	68	65.4	18.8	300	288.4	82.7
Diff.	Dep.	Lat.	Diff.	Dep.	Lat.	Diff.	Dep.	Lat.
	74 Deg.			74 Deg.			74 Deg.	



Dif.	17 Deg.		Dif.	17 Deg.		Dif.	17 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	1.0	.3	35	33.5	10.2	69	66.0	20.2
2	1.9	.6	36	34.4	10.5	70	66.9	20.5
3	2.9	.9	37	35.4	10.8	71	67.9	20.7
4	3.8	1.2	38	36.3	11.1	72	68.8	21.0
5	4.8	1.5	39	37.3	11.4	73	69.8	21.3
6	5.7	1.7	40	38.3	11.7	74	70.8	21.6
7	6.7	2.0	41	39.2	12.0	75	71.7	21.9
8	7.6	2.3	42	40.2	12.3	76	72.7	22.2
9	8.6	2.6	43	41.1	12.6	77	73.6	22.5
10	9.6	2.9	44	42.1	12.9	78	74.6	22.8
11	10.5	3.2	45	43.0	13.1	79	75.5	23.1
12	11.5	3.5	46	44.0	13.4	80	76.5	23.4
13	12.4	3.8	47	44.9	13.7	81	77.5	23.7
14	13.4	4.1	48	45.9	14.0	82	78.4	24.0
15	14.3	4.4	49	46.9	14.3	83	79.4	24.3
16	15.3	4.7	50	47.8	14.6	84	80.3	24.6
17	16.2	5.0	51	48.8	14.9	85	81.3	24.8
18	17.2	5.2	52	49.7	15.2	86	82.2	25.1
19	18.2	5.5	53	50.7	15.5	87	83.2	25.4
20	19.1	5.8	54	51.6	15.8	88	84.2	25.7
21	20.1	6.1	55	52.6	16.1	89	85.1	26.0
22	21.0	6.4	56	53.5	16.4	90	86.1	26.3
23	22.0	6.7	57	54.5	16.7	91	87.0	26.6
24	23.0	7.0	58	55.4	17.0	92	88.0	26.9
25	23.9	7.3	59	56.4	17.2	93	88.9	27.2
26	24.9	7.6	60	57.4	17.5	94	89.9	27.5
27	25.8	7.9	61	58.3	17.8	95	90.8	27.8
28	26.8	8.2	62	59.3	18.1	96	91.8	28.1
29	27.7	8.5	63	60.2	18.4	97	92.7	28.4
30	28.7	8.8	64	61.2	18.7	98	93.7	28.7
31	29.6	9.1	65	62.2	19.0	99	94.7	28.9
32	30.6	9.3	66	63.1	19.3	100	95.6	29.2
33	31.6	9.6	67	64.1	19.6	200	191.3	58.5
34	32.5	9.9	68	65.0	19.9	300	286.9	87.7
Dif.	Dep.	Lat.	Dif.	Dep.	Lat.	Dif.	Dep.	Lat.
	73 Deg.			73 Deg.			73 Deg.	



Diff.	18 Deg.		Diff.	18 Deg.		Diff.	18 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	1.0	.3	35	33.3	10.8	69	65.8	21.3
2	1.9	.6	36	34.2	11.1	70	66.6	21.6
3	2.8	.9	37	35.2	11.4	71	67.5	21.9
4	3.8	1.2	38	36.1	11.7	72	68.5	22.2
5	4.7	1.5	39	37.1	12.0	73	69.4	22.5
6	5.7	1.8	40	38.0	12.4	74	70.4	22.9
7	6.6	2.2	41	39.0	12.7	75	71.3	23.2
8	7.6	2.5	42	39.8	13.0	76	72.3	23.5
9	8.5	2.8	43	40.8	13.3	77	73.2	33.8
10	9.5	3.1	44	41.7	13.6	78	74.2	24.1
11	10.4	3.4	45	42.7	13.9	79	75.1	24.4
12	11.4	3.7	46	43.6	14.2	80	76.1	24.7
13	12.3	4.0	47	44.6	14.5	81	77.0	25.0
14	13.3	4.3	48	45.6	14.8	82	78.0	25.3
15	14.2	4.6	49	46.5	15.1	83	78.9	25.6
16	15.2	5.0	50	47.5	15.4	84	79.9	26.0
17	16.1	5.3	51	48.5	15.8	85	80.8	26.3
18	17.1	5.6	52	49.4	16.1	86	81.8	26.6
19	18.0	5.9	53	50.4	16.4	87	82.7	26.9
20	19.0	6.2	54	51.4	16.7	88	83.7	27.2
21	20.0	6.5	55	52.3	17.0	89	84.6	27.5
22	20.9	6.8	56	53.3	17.3	90	85.6	27.8
23	21.9	7.1	57	54.2	17.6	91	86.5	28.1
24	22.8	7.4	58	55.2	17.9	92	87.5	28.4
25	23.8	7.7	59	56.1	18.2	93	88.4	28.7
26	24.7	8.1	60	57.1	18.5	94	89.4	29.0
27	25.7	8.4	61	58.0	18.8	95	90.3	29.3
28	26.6	8.7	62	59.0	19.2	96	91.3	29.7
29	27.6	9.0	63	59.9	19.5	97	92.2	30.0
30	28.5	9.3	64	60.9	19.8	98	93.2	30.3
31	29.5	9.6	65	61.8	20.1	99	94.1	30.6
32	30.4	9.9	66	62.8	20.4	100	95.1	30.9
33	31.4	10.2	67	63.7	20.7	200	190.2	61.8
34	32.3	10.5	68	64.7	21.0	300	285.3	92.7
Diff.	Dep.	Lat.	Diff.	Dep.	Lat.	Diff.	Dep.	Lat.
	72 Deg.			72 Deg.			72 Deg.	



Diff.	19 Deg.		Diff.	19 Deg.		Diff.	19 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	.9	.3	35	33.1	11.4	69	65.2	22.5
2	1.9	.6	36	34.0	11.7	70	66.2	22.8
3	2.8	1.0	37	35.0	12.1	71	67.1	23.1
4	3.8	1.3	38	35.9	12.4	72	68.1	23.4
5	4.7	1.6	39	36.9	12.7	73	69.0	23.8
6	5.7	2.0	40	37.8	13.0	74	69.9	24.1
7	6.6	2.3	41	38.8	13.4	75	70.9	24.4
8	7.5	2.6	42	39.7	13.7	76	71.8	24.7
9	8.5	2.9	43	40.7	14.0	77	72.8	25.1
10	9.4	3.3	44	41.6	14.3	78	73.7	25.4
11	10.4	3.6	45	42.5	14.7	79	74.7	25.7
12	11.3	3.9	46	43.5	15.0	80	75.6	26.1
13	12.3	4.2	47	44.4	15.3	81	76.6	26.4
14	13.2	4.6	48	45.4	15.6	82	77.5	26.7
15	14.2	4.9	49	46.3	16.0	83	78.5	27.0
16	15.1	5.2	50	47.3	16.3	84	79.4	27.4
17	16.1	5.5	51	48.2	16.6	85	80.4	27.7
18	17.0	5.9	52	49.2	16.9	86	81.3	28.0
19	18.0	6.2	53	50.1	17.3	87	82.2	28.3
20	18.9	6.5	54	51.0	17.6	88	83.2	28.7
21	19.9	6.8	55	52.0	17.9	89	84.1	29.0
22	20.8	7.2	56	52.9	18.2	90	85.1	29.3
23	21.7	7.5	57	53.9	18.6	91	86.0	29.6
24	22.7	7.8	58	54.8	18.9	92	87.0	30.0
25	23.6	8.2	59	55.8	19.2	93	87.9	30.3
26	24.6	8.5	60	56.7	19.5	94	88.9	30.6
27	25.5	8.8	61	57.7	19.9	95	89.8	30.9
28	26.5	9.1	62	58.6	20.2	96	90.8	31.3
29	27.4	9.4	63	59.6	20.5	97	91.7	31.6
30	28.4	9.8	64	60.5	20.8	98	92.6	31.9
31	29.3	10.1	65	61.5	21.2	99	93.6	32.2
32	30.3	10.4	66	62.4	21.5	100	94.5	32.6
33	31.2	10.7	67	63.4	21.8	200	189.1	65.1
34	32.1	11.1	68	64.3	22.2	300	283.6	97.7
Diff.	Dep.	Lat.	Diff.	Dep.	Lat.	Diff.	Dep.	Lat.
	71 Deg.			71 Deg.			71 Deg.	



Diff.	20 Deg.		Diff.	20 Deg.		Diff.	20 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	.9	.3	35	32.9	12.0	69	64.8	23.6
2	1.9	.7	36	33.8	12.3	70	65.8	23.9
3	2.8	1.0	37	34.8	12.6	71	66.7	24.3
4	3.8	1.4	38	35.7	13.0	72	67.7	24.6
5	4.7	1.7	39	36.6	13.3	73	68.6	25.0
6	5.6	2.0	40	37.6	13.7	74	69.5	25.3
7	6.6	2.4	41	38.5	14.0	75	70.5	25.6
8	7.5	2.7	42	39.5	14.4	76	71.4	26.0
9	8.5	3.1	43	40.4	14.7	77	72.4	26.3
10	9.4	3.4	44	41.3	15.0	78	73.3	26.7
11	10.3	3.8	45	42.3	15.4	79	74.2	27.0
12	11.3	4.1	46	43.2	15.7	80	75.2	27.4
13	12.2	4.4	47	44.2	16.1	81	76.1	27.7
14	13.2	4.8	48	45.1	16.4	82	77.1	28.0
15	14.1	5.1	49	46.0	16.8	83	78.0	28.4
16	15.0	5.5	50	47.0	17.1	84	78.9	28.7
17	16.0	5.8	51	47.9	17.4	85	80.0	29.1
18	16.9	6.1	52	48.9	17.8	86	80.8	29.4
19	17.9	6.5	53	49.8	18.1	87	81.8	29.8
20	18.8	6.8	54	50.7	18.5	88	82.7	30.1
21	19.7	7.2	55	51.7	18.8	89	83.6	30.4
22	20.7	7.5	56	52.6	19.1	90	84.6	30.8
23	21.6	7.9	57	53.6	19.5	91	85.5	31.1
24	22.6	8.2	58	54.5	19.8	92	86.4	31.5
25	23.5	8.5	59	55.4	20.2	93	87.4	31.8
26	24.4	8.9	60	56.4	20.5	94	88.3	32.1
27	25.4	9.2	61	57.3	20.9	95	89.3	32.5
28	26.3	9.6	62	58.3	21.2	96	90.2	32.8
29	27.2	10.0	63	59.2	21.5	97	91.2	33.2
30	28.2	10.3	64	60.1	21.9	98	92.1	33.5
31	29.1	10.6	65	61.1	22.2	99	93.0	33.9
32	30.1	10.9	66	62.0	22.6	100	94.0	34.2
33	31.0	11.3	67	63.0	22.9	200	187.9	68.4
34	31.9	11.6	68	63.9	23.3	300	281.9	102.6
Diff.	Dep.	Lat.	Diff.	Dep.	Lat.	Diff.	Dep.	Lat.
	70 Deg.			70 Deg.			70 Deg.	



Diff.	21 Deg.		Diff.	21 Deg.		Diff.	24 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	.9	.4	35	32.7	12.5	69	64.4	24.7
2	1.9	.7	36	33.6	12.9	70	65.3	25.1
3	2.8	1.1	37	34.5	13.2	71	66.3	25.4
4	3.7	1.4	38	35.5	13.6	72	67.2	25.8
5	4.7	1.8	39	36.4	14.0	73	68.1	26.2
6	5.6	2.1	40	37.3	14.3	74	69.1	26.5
7	6.5	2.5	41	38.3	14.7	75	70.0	26.9
8	7.5	2.9	42	39.2	15.0	76	70.9	27.2
9	8.4	3.2	43	40.1	15.4	77	71.9	27.6
10	9.3	3.6	44	41.1	15.8	78	72.8	27.9
11	10.3	3.9	45	42.0	16.1	79	73.7	28.3
12	11.2	4.3	46	42.9	16.5	80	74.7	28.7
13	12.1	4.7	47	43.9	16.8	81	75.6	29.0
14	13.1	5.0	48	44.8	17.2	82	76.6	29.4
15	14.0	5.4	49	45.7	17.6	83	77.5	29.7
16	14.9	5.7	50	46.7	17.9	84	78.4	30.1
17	15.9	6.1	51	47.6	18.3	85	79.4	30.5
18	16.8	6.4	52	48.5	18.6	86	80.3	30.8
19	17.7	6.8	53	49.5	19.0	87	81.2	31.2
20	18.7	7.2	54	50.4	19.3	88	82.2	31.5
21	19.6	7.5	55	51.3	19.7	89	83.1	31.9
22	20.5	7.9	56	52.3	20.1	90	84.0	32.3
23	21.5	8.2	57	53.2	20.4	91	84.9	32.6
24	22.4	8.6	58	54.1	20.8	92	85.9	33.0
25	23.3	9.0	59	55.1	21.1	93	86.8	33.3
26	24.3	9.3	60	56.0	21.5	94	87.7	33.7
27	25.2	9.7	61	56.9	21.9	95	88.7	34.0
28	26.1	10.0	62	57.9	22.2	96	89.6	34.4
29	27.1	10.4	63	58.8	22.6	97	90.5	34.8
30	28.0	10.7	64	59.8	22.9	98	91.5	35.1
31	28.9	11.1	65	60.7	23.3	99	92.4	35.5
32	29.9	11.5	66	61.6	23.6	100	93.4	35.8
33	30.8	11.8	67	62.6	24.0	200	186.7	71.7
34	31.7	12.2	68	63.5	24.4	300	280.1	107.5
Diff.	Dep.	Lat.	Diff.	Dep.	Lat.	Diff.	Dep.	Lat.
	69 Deg.			69 Deg.			69 Deg.	



Diff.	22 Deg.		Diff.	22 Deg.		Diff.	22 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	.9	.4	35	32.4	13.1	69	64.0	25.9
2	1.9	.7	36	33.4	13.5	70	64.9	26.2
3	2.8	1.1	37	34.3	13.9	71	65.8	26.5
4	3.7	1.5	38	35.2	14.2	72	66.7	27.0
5	4.6	1.9	39	36.1	14.6	73	67.7	27.4
6	5.6	2.2	40	37.1	15.0	74	68.6	27.7
7	6.5	2.6	41	38.0	15.4	75	69.5	28.1
8	7.4	3.0	42	38.9	15.7	76	70.5	28.5
9	8.3	3.4	43	39.9	16.1	77	71.4	28.9
10	9.3	3.7	44	40.8	16.5	78	72.3	29.2
11	10.2	4.1	45	41.7	16.9	79	73.3	29.6
12	11.1	4.5	46	42.6	17.2	80	74.2	30.0
13	12.0	4.9	47	43.6	17.6	81	75.1	30.4
14	13.0	5.2	48	44.5	18.0	82	76.0	30.7
15	13.9	5.6	49	45.4	18.4	83	77.0	31.1
16	14.8	6.0	50	46.4	18.7	84	77.9	31.5
17	15.7	6.4	51	47.3	19.1	85	78.8	31.9
18	16.7	6.7	52	48.2	19.5	86	79.7	32.2
19	17.6	7.1	53	49.1	19.9	87	80.6	32.6
20	18.5	7.5	54	50.1	20.2	88	81.6	33.0
21	19.5	7.9	55	51.0	20.6	89	82.5	33.4
22	20.4	8.2	56	51.9	21.0	90	83.4	33.7
23	21.3	8.6	57	52.9	21.4	91	84.4	34.1
24	22.2	9.0	58	53.8	21.7	92	85.3	34.5
25	23.2	9.4	59	54.7	22.1	93	86.2	34.9
26	24.1	9.7	60	55.6	22.5	94	87.1	35.2
27	25.0	10.1	61	56.6	22.9	95	88.1	35.6
28	26.0	10.5	62	57.5	23.2	96	89.0	36.0
29	26.9	10.9	63	58.4	23.6	97	89.9	36.4
30	27.8	11.2	64	59.4	24.0	98	90.9	36.7
31	28.7	11.6	65	60.3	24.4	99	91.8	37.1
32	29.7	12.0	66	61.2	24.7	100	92.7	37.5
33	30.6	12.4	67	62.1	25.1	200	185.4	74.9
34	31.5	12.7	68	63.1	25.5	300	278.2	112.4
Diff.	Dep.	Lat.	Diff.	Dep.	Lat.	Diff.	Dep.	Lat.
	68 Deg.			68 Deg.			68 Deg.	



Diff.	23 Deg.		Diff.	23 Deg.		Diff.	23 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	.9	.4	35	32.2	13.7	69	63.5	26.9
2	1.8	.8	36	33.1	14.1	70	64.4	27.3
3	2.8	1.2	37	34.0	14.4	71	65.3	27.7
4	3.7	1.6	38	35.0	14.8	72	66.3	28.1
5	4.6	1.9	39	35.9	15.2	73	67.2	28.5
6	5.5	2.3	40	36.8	15.6	74	68.1	28.9
7	6.4	2.7	41	37.7	16.0	75	69.0	29.3
8	7.4	3.1	42	38.6	16.4	76	69.9	29.7
9	8.3	3.5	43	39.6	16.8	77	70.9	30.1
10	9.2	3.9	44	40.5	17.2	78	71.8	30.5
11	10.1	4.3	45	41.4	17.6	79	72.7	30.8
12	11.0	4.7	46	42.3	18.0	80	73.6	31.2
13	12.0	5.1	47	43.3	18.4	81	74.6	31.6
14	12.9	5.5	48	44.2	18.7	82	75.5	32.0
15	13.8	5.9	49	45.1	19.1	83	76.4	32.4
16	14.7	6.2	50	46.0	19.5	84	77.3	32.8
17	15.6	6.6	51	46.9	19.9	85	78.2	33.2
18	16.6	7.0	52	47.9	20.3	86	79.2	33.6
19	17.5	7.4	53	48.8	20.7	87	80.1	34.0
20	18.4	7.8	54	49.7	21.1	88	81.0	34.4
21	19.3	8.2	55	50.6	21.5	89	81.9	34.8
22	20.2	8.6	56	51.5	21.9	90	82.8	35.2
23	21.2	9.0	57	52.4	22.3	91	83.8	35.6
24	22.1	9.4	58	53.4	22.6	92	84.7	36.0
25	23.0	9.8	59	54.3	23.0	93	85.6	36.3
26	23.9	10.2	60	55.2	23.4	94	86.5	36.7
27	24.8	10.5	61	56.1	23.8	95	87.4	37.0
28	25.8	10.9	62	57.1	24.2	96	88.4	37.5
29	26.7	11.3	63	58.0	24.6	97	89.3	37.9
30	27.6	11.7	64	58.9	25.0	98	90.2	38.3
31	28.5	12.1	65	59.8	25.4	99	91.1	38.7
32	29.4	12.5	66	60.8	25.8	100	92.0	39.1
33	30.4	12.9	67	61.7	26.2	200	184.1	78.1
34	31.3	13.3	68	62.6	26.6	300	276.1	117.2
Diff.	Dep.	Lat.	Diff.	Dep.	Lat.	Diff.	Dep.	Lat.
	67 Deg.			67 Deg.			67 Deg.	



Diff.	24 Deg.		Diff.	24 Deg.		Diff.	24 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	.9	.4	35	32.0	14.2	69	63.0	28.1
2	1.8	.8	36	32.9	14.6	70	63.9	28.5
3	2.7	1.2	37	33.8	15.1	71	64.8	28.9
4	3.6	1.6	38	34.7	15.5	72	65.8	29.3
5	4.6	2.0	39	35.6	15.9	73	66.7	29.7
6	5.5	2.4	40	36.5	16.3	74	67.6	30.1
7	6.4	2.8	41	37.4	16.7	75	68.5	30.5
8	7.3	3.2	42	38.4	17.1	76	69.4	30.9
9	8.2	3.7	43	39.3	17.5	77	70.3	31.3
10	9.1	4.1	44	40.2	17.9	78	71.2	31.7
11	10.0	4.5	45	41.1	18.3	79	72.1	32.1
12	10.9	4.9	46	42.0	18.7	80	73.1	32.5
13	11.9	5.3	47	42.9	19.1	81	74.0	32.9
14	12.8	5.7	48	43.8	19.5	82	74.9	33.3
15	13.7	6.1	49	44.8	19.9	83	75.8	33.7
16	14.6	6.5	50	45.7	20.3	84	76.7	34.1
17	15.5	6.9	51	46.6	20.7	85	77.6	34.5
18	16.4	7.3	52	47.5	21.1	86	78.5	34.9
19	17.3	7.7	53	48.4	21.6	87	79.5	35.3
20	18.3	8.1	54	49.3	22.0	88	80.4	35.7
21	19.2	8.5	55	50.2	22.4	89	81.3	36.2
22	20.1	9.0	56	51.1	22.8	90	82.2	36.6
23	21.0	9.4	57	52.1	23.2	91	83.1	37.0
24	21.9	9.8	58	53.0	23.6	92	84.0	37.4
25	22.8	10.2	59	53.9	24.0	93	84.9	37.8
26	23.7	10.6	60	54.8	24.4	94	85.8	38.2
27	24.6	11.0	61	55.7	24.8	95	86.8	38.6
28	25.6	11.3	62	56.6	25.2	96	87.7	39.0
29	26.5	11.7	63	57.5	25.6	97	88.6	39.5
30	27.4	12.2	64	58.5	26.0	98	89.5	39.9
31	28.3	12.6	65	59.4	26.4	99	90.4	40.3
32	29.2	13.0	66	60.3	26.8	100	91.3	40.7
33	30.1	13.4	67	61.2	27.2	200	182.7	81.3
34	31.0	13.8	68	62.1	27.6	300	274.0	122.0
Diff.	Dep.	Lat.	Diff.	Dep.	Lat.	Diff.	Dep.	Lat.
	66 Deg.			66 Deg.			66 Deg.	



Dif.	25 Deg.		Dif.	25 Deg.		Dif.	25 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	.9	.4	35	31.7	14.8	69	62.5	29.2
2	1.8	.8	36	32.6	15.2	70	63.4	29.6
3	2.7	1.3	37	33.5	15.6	71	64.3	30.0
4	3.6	1.7	38	34.4	16.1	72	65.2	30.5
5	4.5	2.1	39	35.3	16.5	73	66.2	30.9
6	5.4	2.5	40	36.2	16.9	74	67.1	31.3
7	6.3	3.0	41	37.2	17.3	75	68.0	31.7
8	7.2	3.4	42	38.1	17.8	76	68.9	32.1
9	8.1	3.8	43	39.0	18.2	77	69.8	32.6
10	9.1	4.2	44	39.9	18.6	78	70.7	33.0
11	10.0	4.7	45	40.8	19.0	79	71.6	33.4
12	10.9	5.1	46	41.7	19.5	80	72.5	33.8
13	11.8	5.5	47	42.6	19.9	81	73.4	34.3
14	12.7	5.9	48	43.5	20.3	82	74.3	34.7
15	13.6	6.3	49	44.4	20.7	83	75.2	35.1
16	14.5	6.8	50	45.3	21.1	84	76.1	35.5
17	15.4	7.2	51	46.2	21.6	85	77.0	36.0
18	16.3	7.6	52	47.1	22.0	86	77.9	36.4
19	17.2	8.0	53	48.0	22.4	87	78.8	36.8
20	18.1	8.4	54	48.9	22.8	88	79.7	37.2
21	19.0	8.9	55	49.8	23.2	89	80.7	37.6
22	19.9	9.3	56	50.7	23.7	90	81.6	38.0
23	20.8	9.7	57	51.6	24.1	91	82.5	38.4
24	21.8	10.1	58	52.6	24.5	92	83.4	38.9
25	22.7	10.6	59	53.5	25.0	93	84.3	39.3
26	23.6	11.0	60	54.4	25.4	94	85.2	39.7
27	24.5	11.4	61	55.3	25.8	95	86.1	40.1
28	25.4	11.8	62	56.2	26.2	96	87.0	40.6
29	26.3	12.3	63	57.1	26.7	97	87.9	41.0
30	27.2	12.7	64	58.0	27.1	98	88.8	41.4
31	28.1	13.1	65	58.9	27.5	99	89.7	41.8
32	29.0	13.5	66	59.8	27.9	100	90.6	42.3
33	29.9	14.0	67	60.7	28.3	200	181.3	48.5
34	30.8	14.4	68	61.6	28.8	300	271.9	126.8
Dif.	Dep.	Lat.	Dif.	Dep.	Lat.	Dif.	Dep.	Lat.
	65 Deg.			65 Deg.			65 Deg.	



Diff.	26 Deg.		Diff.	26 Deg.		Diff.	26 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	.9	.4	35	31.5	15.3	69	62.0	30.2
2	1.8	.9	36	32.4	15.8	70	62.9	30.7
3	2.7	1.3	37	33.3	16.2	71	63.8	31.1
4	3.6	1.8	38	34.2	16.6	72	64.7	31.5
5	4.5	2.2	39	35.1	17.1	73	65.6	32.0
6	5.4	2.6	40	36.0	17.5	74	66.5	32.4
7	6.3	3.1	41	36.8	17.9	75	67.4	32.9
8	7.2	3.5	42	37.8	18.4	76	68.3	33.3
9	8.1	3.9	43	38.6	18.8	77	69.2	33.8
10	9.0	4.4	44	39.5	19.3	78	70.1	34.2
11	9.9	4.8	45	40.4	19.7	79	71.0	34.6
12	10.8	5.3	46	41.3	20.2	80	71.9	35.1
13	11.7	5.7	47	42.2	20.6	81	72.8	35.5
14	12.6	6.1	48	43.1	21.0	82	73.7	35.9
15	13.5	6.6	49	44.0	21.4	83	74.6	36.4
16	14.4	7.0	50	44.9	21.9	84	75.5	36.8
17	15.3	7.4	51	45.8	22.3	85	76.4	37.2
18	16.2	7.9	52	46.7	22.8	86	77.3	37.7
19	17.1	8.3	53	47.6	23.2	87	78.2	38.5
20	18.0	8.8	54	48.5	23.7	88	79.1	38.1
21	18.9	9.2	55	49.4	24.1	89	80.0	39.0
22	19.8	9.6	56	50.3	24.5	90	80.9	39.4
23	20.7	10.1	57	51.2	25.0	91	81.8	39.9
24	21.6	10.5	58	52.1	25.4	92	82.7	40.3
25	22.5	10.9	59	53.0	25.8	93	83.6	40.7
26	23.4	11.4	60	53.9	26.3	94	84.5	41.2
27	24.3	11.8	61	54.8	26.7	95	85.4	41.6
28	25.2	12.3	62	55.7	27.2	96	86.3	42.1
29	26.1	12.7	63	56.6	27.6	97	87.2	42.5
30	27.0	13.1	64	57.5	28.0	98	88.1	42.9
31	27.9	13.6	65	58.4	28.5	99	89.0	43.4
32	28.8	14.0	66	59.3	28.9	100	89.9	43.8
33	29.7	14.4	67	60.2	29.4	200	179.8	87.7
34	30.6	14.9	68	61.1	29.8	300	269.6	131.5
Diff.	Dep.	Lat.	Diff.	Dep.	Lat.	Diff.	Dep.	Lat.
	64 Deg.			64 Deg.			64 Deg.	



Diff.	27 Deg.		Diff.	27 Deg.		Diff.	27 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	.9	.5	35	31.2	15.9	69	61.5	31.3
2	1.8	.9	36	32.1	16.3	70	62.4	31.8
3	2.7	1.4	37	33.0	16.8	71	63.3	32.2
4	3.6	1.8	38	33.8	17.2	72	64.1	32.7
5	4.5	2.3	39	34.7	17.7	73	65.0	33.2
6	5.3	2.7	40	35.6	18.2	74	65.9	33.6
7	6.2	3.2	41	36.5	18.6	75	66.8	34.1
8	7.1	3.6	42	37.4	19.1	76	67.7	34.5
9	8.0	4.1	43	38.3	19.5	77	68.6	35.0
10	8.9	4.5	44	39.1	20.0	78	69.5	35.4
11	9.8	5.0	45	40.1	20.4	79	70.4	35.9
12	10.7	5.4	46	41.0	20.9	80	71.3	36.3
13	11.6	5.9	47	41.9	21.3	81	72.2	36.8
14	12.5	6.3	48	42.8	21.8	82	73.1	37.2
15	13.4	6.8	49	43.6	22.2	83	73.9	37.7
16	14.3	7.2	50	44.5	22.7	84	74.8	38.1
17	15.1	7.7	51	45.4	23.2	85	75.7	38.6
18	16.0	8.2	52	46.3	23.6	86	76.6	39.0
19	16.9	8.6	53	47.2	24.1	87	77.5	39.5
20	17.8	9.1	54	48.1	24.5	88	78.4	40.0
21	18.7	9.5	55	49.0	25.0	89	79.3	40.4
22	19.6	10.0	56	49.9	25.4	90	80.2	40.9
23	20.5	10.4	57	50.8	25.9	91	81.1	41.3
24	21.4	10.9	58	51.7	26.3	92	82.0	41.8
25	22.3	11.3	59	52.6	26.8	93	82.9	42.2
26	23.2	11.8	60	53.5	27.2	94	83.7	42.7
27	24.1	12.2	61	54.3	27.7	95	84.6	43.1
28	24.9	12.7	62	55.2	28.2	96	85.5	43.6
29	25.8	13.2	63	56.1	28.6	97	86.4	44.0
30	26.7	13.6	64	57.0	29.1	98	87.3	44.5
31	27.6	14.1	65	57.9	29.5	99	88.2	44.9
32	28.5	14.5	66	58.8	30.0	100	89.1	45.4
33	29.4	15.0	67	59.7	30.4	200	178.2	90.9
34	30.3	15.4	68	60.6	30.9	300	267.3	136.3
Diff.	Dep.	Lat.	Diff.	Dep.	Lat.	Diff.	Dep.	Lat.
	63 Deg.			63 Deg.			63 Deg.	



Diff.	28 Deg.		Diff.	28 Deg.		Diff.	28 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	.9	.5	35	30.9	16.4	69	60.9	32.4
2	1.8	.9	36	31.8	16.9	70	61.8	32.9
3	2.6	1.4	37	32.6	17.4	71	62.7	33.3
4	3.5	1.9	38	33.5	17.8	72	63.6	33.8
5	4.4	2.3	39	34.4	18.3	73	64.4	34.3
6	5.3	2.8	40	35.3	18.8	74	65.3	34.7
7	6.2	3.3	41	36.2	19.2	75	66.2	35.2
8	7.1	3.7	42	37.1	19.7	76	67.1	35.7
9	7.9	4.2	43	38.0	20.2	77	68.0	36.1
10	8.8	4.7	44	38.8	20.7	78	68.9	36.6
11	9.7	5.2	45	39.7	21.1	79	69.7	37.1
12	10.6	5.6	46	40.6	21.6	80	70.6	37.6
13	11.5	6.1	47	41.5	22.1	81	71.5	38.0
14	12.4	6.6	48	42.4	22.5	82	72.4	38.5
15	13.2	7.0	49	43.2	23.0	83	73.3	39.0
16	14.1	7.5	50	44.1	23.5	84	74.2	39.4
17	15.0	8.0	51	45.0	23.9	85	75.0	39.9
18	15.9	8.4	52	45.9	24.4	86	75.9	40.4
19	16.8	8.9	53	46.8	24.9	87	76.8	40.8
20	17.7	9.4	54	47.7	25.4	88	77.7	41.3
21	18.5	9.9	55	48.5	25.8	89	78.6	41.8
22	19.4	10.3	56	49.4	26.3	90	79.5	42.2
23	20.3	10.8	57	50.3	26.8	91	80.3	42.7
24	21.2	11.3	58	51.2	27.2	92	81.2	43.2
25	22.1	11.7	59	52.1	27.7	93	82.1	43.7
26	23.0	12.2	60	53.0	28.2	94	83.0	44.1
27	23.8	12.7	61	53.8	28.6	95	83.9	44.6
28	24.7	13.1	62	54.7	29.1	96	84.8	45.1
29	25.6	13.6	63	55.6	29.6	97	85.6	45.5
30	26.5	14.1	64	56.5	30.0	98	86.5	46.0
31	27.4	14.5	65	57.4	30.5	99	87.4	46.5
32	28.2	15.0	66	58.3	31.0	100	88.3	46.9
33	29.1	15.5	67	59.1	31.5	200	176.6	93.9
34	30.0	16.0	68	60.0	31.9	300	264.9	140.8
Diff.	Dep.	Lat.	Diff.	Dep.	Lat.	Diff.	Dep.	Lat.
	62 Deg.			62 Deg.			62 Deg.	



Diff.	29 Deg.		Diff.	29 Deg.		Diff.	29 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	.9	.5	35	30.6	17.0	69	60.4	33.4
2	1.7	1.0	36	31.5	17.4	70	61.2	33.9
3	2.6	1.4	37	32.4	17.9	71	62.1	34.4
4	3.5	1.9	38	33.2	18.4	72	63.0	34.9
5	4.4	2.4	39	34.1	18.9	73	63.8	35.4
6	5.2	2.9	40	35.0	19.4	74	64.7	35.9
7	6.1	3.4	41	35.9	19.9	75	65.6	36.3
8	7.0	3.9	42	36.7	20.3	76	66.5	36.8
9	7.9	4.3	43	37.6	20.8	77	67.3	37.3
10	8.7	4.8	44	38.5	21.3	78	68.2	37.8
11	9.6	5.3	45	39.4	21.8	79	69.1	38.3
12	10.5	5.8	46	40.2	22.3	80	70.0	38.8
13	11.4	6.3	47	41.1	22.8	81	70.8	39.3
14	12.2	6.8	48	42.0	23.3	82	71.7	39.7
15	13.1	7.3	49	42.9	23.7	83	72.6	40.2
16	14.0	7.7	50	43.7	24.2	84	73.5	40.7
17	14.9	8.2	51	44.6	24.7	85	74.3	41.2
18	15.7	8.7	52	45.5	25.2	86	75.2	41.7
19	16.6	9.2	53	46.4	25.7	87	76.1	42.2
20	17.5	9.7	54	47.2	26.2	88	77.0	42.7
21	18.4	10.2	55	48.1	26.7	89	77.8	43.1
22	19.2	10.7	56	49.0	27.1	90	78.7	43.6
23	20.1	11.1	57	49.9	27.6	91	79.6	44.1
24	21.0	11.6	58	50.7	28.1	92	80.5	44.6
25	21.9	12.1	59	51.6	28.6	93	81.3	45.1
26	22.7	12.6	60	52.5	29.1	94	82.2	45.6
27	23.6	13.1	61	53.4	29.6	95	83.1	46.1
28	24.5	13.6	62	54.2	30.1	96	84.0	46.5
29	25.4	14.1	63	55.1	30.5	97	84.8	47.0
30	26.2	14.5	64	56.0	31.0	98	85.7	47.5
31	27.1	15.0	65	56.9	31.5	99	86.6	48.0
32	28.0	15.5	66	57.7	32.0	100	87.5	48.5
33	28.9	16.0	67	58.6	32.5	200	174.9	97.0
34	29.7	16.5	68	59.5	33.0	300	262.4	145.4
Diff.	Dep.	Lat.	Diff.	Dep.	Lat.	Diff.	Dep.	Lat.
	61 Deg.			61 Deg.			61 Deg.	



Dift.	30 Deg.		Dift.	30 Deg.		Dift.	30 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	.9	.5	35	30.3	17.5	69	59.8	34.5
2	1.7	1.0	36	31.2	18.0	70	60.6	35.0
3	2.6	1.5	37	32.0	18.5	71	61.5	35.5
4	3.5	2.0	38	32.9	19.0	72	62.3	36.0
5	4.3	2.5	39	33.8	19.5	73	63.2	36.5
6	5.2	3.0	40	34.6	20.0	74	64.1	37.0
7	6.1	3.5	41	35.5	20.5	75	64.9	37.5
8	6.9	4.0	42	36.4	21.0	76	65.8	38.0
9	7.8	4.5	43	37.2	21.5	77	66.7	38.5
10	8.7	5.0	44	38.1	22.0	78	67.6	39.0
11	9.5	5.5	45	39.0	22.5	79	68.4	39.5
12	10.4	6.0	46	39.8	23.0	80	69.3	40.0
13	11.3	6.5	47	40.7	23.5	81	70.2	40.5
14	12.1	7.0	48	41.6	24.0	82	71.0	41.0
15	13.0	7.5	49	42.4	24.5	83	71.9	41.5
16	13.9	8.0	50	43.3	25.0	84	72.7	42.0
17	14.7	8.5	51	44.2	25.5	85	73.6	42.5
18	15.6	9.0	52	45.0	26.0	86	74.5	43.0
19	16.5	9.5	53	45.9	26.5	87	75.3	43.5
20	17.3	10.0	54	46.8	27.0	88	76.2	44.0
21	18.2	10.5	55	47.6	27.5	89	77.1	44.5
22	19.1	11.0	56	48.5	28.0	90	77.9	45.0
23	19.9	11.5	57	49.4	28.5	91	78.8	45.5
24	20.8	12.0	58	50.2	29.0	92	79.7	46.0
25	21.7	12.5	59	51.1	29.5	93	80.6	46.5
26	22.5	13.0	60	52.0	30.0	94	81.4	47.0
27	23.4	13.5	61	52.8	30.5	95	82.3	47.5
28	24.2	14.0	62	53.7	31.0	96	83.2	48.0
29	25.1	14.5	63	54.6	31.5	97	84.0	48.5
30	26.0	15.0	64	55.4	32.0	98	84.9	49.0
31	26.8	15.5	65	56.3	32.5	99	85.7	49.5
32	27.7	16.0	66	57.2	33.0	100	86.6	50.0
33	28.6	16.5	67	58.0	33.5	200	173.2	100.5
34	29.4	17.0	68	58.9	34.0	300	259.8	150.0
Dift.	Dep.	Lat.	Dift.	Dep.	Lat.	Dift.	Dep.	Lat.
	60 Deg.			60 Deg.			60 Deg.	



Diff.	31 Deg.		Diff.	31 Deg.		Diff.	31 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	.9	.5	35	30.0	18.0	69	59.1	35.5
2	1.7	1.0	36	30.9	18.5	70	60.0	36.0
3	2.6	1.5	37	31.7	19.1	71	60.9	36.6
4	3.4	2.1	38	32.6	19.6	72	61.7	37.1
5	4.3	2.6	39	33.4	20.1	73	62.6	37.6
6	5.1	3.1	40	34.3	20.6	74	63.4	38.1
7	6.0	3.6	41	35.1	21.1	75	64.3	38.6
8	6.9	4.1	42	36.0	21.6	76	65.1	39.1
9	7.7	4.6	43	36.9	22.1	77	66.0	39.7
10	8.6	5.1	44	37.7	22.7	78	66.9	40.2
11	9.4	5.7	45	38.6	23.2	79	67.7	40.7
12	10.3	6.2	46	39.4	23.7	80	68.6	41.2
13	11.1	6.7	47	40.3	24.2	81	69.4	41.7
14	12.0	7.2	48	41.1	24.7	82	70.3	42.2
15	12.9	7.7	49	42.0	25.2	83	71.1	42.7
16	13.7	8.2	50	42.9	25.7	84	72.0	43.3
17	14.6	8.8	51	43.7	26.3	85	72.9	43.8
18	15.4	9.3	52	44.6	26.8	86	73.7	44.3
19	16.3	9.8	53	45.4	27.3	87	74.6	44.8
20	17.1	10.3	54	46.3	27.8	88	75.4	45.3
21	18.0	10.8	55	47.1	28.3	89	76.3	45.8
22	18.9	11.3	56	48.0	28.8	90	77.1	46.3
23	19.7	11.8	57	48.9	29.4	91	78.0	46.9
24	20.6	12.4	58	49.7	29.9	92	78.9	47.4
25	21.4	12.9	59	50.6	30.4	93	79.7	47.9
26	22.3	13.4	60	51.4	30.9	94	80.6	48.4
27	23.1	13.9	61	52.3	31.4	95	81.4	48.9
28	24.0	14.4	62	53.1	31.9	96	82.3	49.4
29	24.9	14.9	63	54.0	32.4	97	83.1	50.0
30	25.7	15.4	64	54.9	33.0	98	84.0	50.5
31	26.6	16.0	65	55.7	33.5	99	84.9	51.0
32	27.4	16.5	66	56.6	34.0	100	85.8	51.5
33	28.3	17.0	67	57.4	34.5	200	171.4	103.0
34	29.2	17.5	68	58.3	35.0	300	257.2	154.5
Diff.	Dep.	Lat.	Diff.	Dep.	Lat.	Diff.	Dep.	Lat.
	59 Deg.			59 Deg.			59 Deg.	



Diff.	32 Deg.		Diff.	32 Deg.		Diff.	32 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	.8	.5	35	29.7	18.5	69	58.5	36.6
2	1.7	1.1	36	30.5	19.1	70	59.4	37.1
3	2.5	1.6	37	31.4	19.6	71	60.2	37.6
4	3.4	2.1	38	32.2	20.1	72	61.0	38.1
5	4.2	2.6	39	33.1	20.7	73	61.9	38.7
6	5.1	3.2	40	33.9	21.2	74	62.7	39.2
7	5.9	3.7	41	34.8	21.7	75	63.6	39.7
8	6.8	4.2	42	35.6	22.3	76	64.4	40.3
9	7.6	4.8	43	36.5	22.8	77	65.3	40.8
10	8.5	5.3	44	37.3	23.3	78	66.1	41.3
11	9.3	5.8	45	38.2	23.8	79	67.0	41.9
12	10.2	6.4	46	39.0	24.4	80	67.8	42.4
13	11.0	6.9	47	39.8	24.9	81	68.7	42.9
14	11.9	7.4	48	40.7	25.4	82	69.5	43.4
15	12.7	7.9	49	41.5	26.0	83	70.3	44.0
16	13.6	8.5	50	42.4	26.5	84	71.2	44.5
17	14.4	9.0	51	43.2	27.0	85	72.1	45.0
18	15.3	9.5	52	44.1	27.5	86	72.9	45.6
19	16.1	10.1	53	44.9	28.1	87	73.8	46.1
20	17.0	10.6	54	45.8	28.6	88	74.6	46.6
21	17.8	11.1	55	46.6	29.1	89	75.5	47.2
22	18.7	11.7	56	47.5	29.7	90	76.3	47.7
23	19.5	12.2	57	48.3	30.2	91	77.2	48.2
24	20.4	12.7	58	49.2	30.7	92	78.0	48.7
25	21.2	13.2	59	50.0	31.3	93	78.8	49.3
26	22.0	13.8	60	50.9	31.8	94	79.7	49.8
27	22.9	14.3	61	51.7	32.3	95	80.5	50.3
28	23.7	14.8	62	52.6	32.9	96	81.4	50.9
29	24.6	15.3	63	53.4	33.4	97	82.2	51.4
30	25.4	15.9	64	54.3	33.9	98	83.1	51.9
31	26.3	16.4	65	55.1	34.4	99	83.9	52.4
32	27.1	17.0	66	56.0	35.0	100	84.8	53.0
33	28.0	17.5	67	56.8	35.5	200	169.6	106.0
34	28.8	18.0	68	57.7	36.0	300	254.4	159.0
Diff.	Dep.	Lat.	Diff.	Dep.	Lat.	Diff.	Dep.	Lat.
	58 Deg.			58 Deg.			58 Deg.	



Diff.	33 Deg.		Diff.	33 Deg.		Diff.	33 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	.8	.5	35	29.4	19.1	69	57.9	37.6
2	1.7	1.1	36	30.2	19.6	70	58.7	38.1
3	2.5	1.6	37	31.1	20.2	71	59.6	38.6
4	3.4	2.2	38	31.9	20.7	72	60.4	39.2
5	4.2	2.7	39	32.7	21.2	73	61.2	39.7
6	5.0	3.3	40	33.5	21.8	74	62.1	40.3
7	5.9	3.8	41	34.4	22.3	75	62.9	40.8
8	6.7	4.4	42	35.2	22.9	76	63.7	41.4
9	7.6	4.9	43	36.1	23.4	77	64.6	41.9
10	8.4	5.4	44	36.9	24.0	78	65.4	42.5
11	9.2	6.0	45	37.7	24.5	79	66.3	43.0
12	10.1	6.5	46	38.6	25.1	80	67.1	43.6
13	10.9	7.1	47	39.4	25.6	81	67.9	44.1
14	11.7	7.6	48	40.3	26.2	82	68.8	44.6
15	12.6	8.2	49	41.1	26.7	83	69.6	45.2
16	13.4	8.7	50	41.9	27.2	84	70.5	45.7
17	14.3	9.3	51	42.8	27.8	85	71.3	46.2
18	15.1	9.8	52	43.6	28.3	86	72.1	46.8
19	15.9	10.4	53	44.5	28.8	87	73.0	47.3
20	16.8	10.9	54	45.3	29.4	88	73.8	47.9
21	17.6	11.4	55	46.1	30.0	89	74.7	48.4
22	18.5	12.0	56	47.0	30.5	90	75.5	49.0
23	19.3	12.5	57	47.8	31.0	91	76.3	49.5
24	20.1	13.1	58	48.7	31.6	92	77.2	50.1
25	21.0	13.6	59	49.5	32.1	93	78.0	50.6
26	21.8	14.2	60	50.3	32.7	94	78.9	51.2
27	22.7	14.7	61	51.2	33.2	95	79.7	51.7
28	23.5	15.3	62	52.0	33.8	96	80.5	52.2
29	24.3	15.8	63	52.9	34.3	97	81.4	52.8
30	25.2	16.3	64	53.7	34.8	98	82.2	53.3
31	26.0	16.9	65	54.5	35.4	99	83.1	53.9
32	26.9	17.4	66	55.4	35.5	100	83.9	54.5
33	27.7	18.0	67	56.2	36.5	200	167.7	108.9
34	28.5	18.5	68	57.1	37.0	300	251.6	163.4
Diff.	Dep.	Lat.	Diff.	Dep.	Lat.	Diff.	Dep.	Lat.
	57 Deg.			57 Deg.			57 Deg.	



Diff.	34 Deg.		Diff.	34 Deg.		Diff.	34 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	.8	.6	35	29.0	19.6	69	57.2	38.6
2	1.7	1.1	36	29.8	20.1	70	58.0	39.1
3	2.5	1.7	37	30.7	20.7	71	58.8	39.7
4	3.3	2.2	38	31.5	21.2	72	59.7	40.3
5	4.1	2.8	39	32.3	21.8	73	60.5	40.8
6	5.0	3.4	40	33.2	22.4	74	61.3	41.4
7	5.8	3.9	41	34.0	22.9	75	62.2	41.9
8	6.6	4.5	42	34.8	23.5	76	63.0	42.5
9	7.5	5.0	43	35.6	24.0	77	63.8	43.1
10	8.3	5.6	44	36.5	24.6	78	64.7	43.6
11	9.1	6.1	45	37.3	25.1	79	65.5	44.2
12	9.9	6.7	46	38.1	25.7	80	66.3	44.7
13	10.8	7.3	47	39.0	26.3	81	67.1	45.3
14	11.6	7.8	48	39.8	26.8	82	68.0	45.8
15	12.4	8.4	49	40.6	27.4	83	68.8	46.4
16	13.3	8.9	50	41.4	28.0	84	69.6	47.0
17	14.1	9.5	51	42.3	28.5	85	70.5	47.5
18	14.9	10.1	52	43.1	29.1	86	71.3	48.1
19	15.8	10.6	53	43.9	29.6	87	72.1	48.6
20	16.6	11.2	54	44.8	30.2	88	72.9	49.2
21	17.4	11.7	55	45.6	30.7	89	73.8	49.8
22	18.2	12.3	56	46.4	31.3	90	74.6	50.3
23	19.1	12.9	57	47.3	31.9	91	75.4	50.9
24	19.9	13.4	58	48.1	32.4	92	76.3	51.4
25	20.7	14.0	59	48.9	33.0	93	77.1	52.0
26	21.6	14.5	60	49.7	33.5	94	77.9	52.6
27	22.4	15.1	61	50.6	34.1	95	78.8	53.1
28	23.2	15.7	62	51.4	34.6	96	79.6	53.7
29	24.0	16.2	63	52.2	35.2	97	80.4	54.2
30	24.9	16.8	64	53.0	35.8	98	81.2	54.8
31	25.7	17.3	65	53.9	36.3	99	82.1	55.4
32	26.5	17.9	66	54.7	36.9	100	82.9	55.9
33	27.4	18.4	67	55.5	37.4	200	165.8	111.8
34	28.2	19.0	68	56.4	38.0	300	248.7	167.8
Diff.	Dep.	Lat.	Diff.	Dep.	Lat.	Diff.	Dep.	Lat.
	56 Deg.			56 Deg.			56 Deg.	



Diff.	35 Deg.		Diff.	35 Deg.		Diff.	35 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	.8	.6	35	28.6	20.1	69	56.5	39.6
2	1.7	1.1	36	29.5	20.6	70	57.3	40.2
3	2.5	1.7	37	30.3	21.2	71	58.2	40.7
4	3.3	2.3	38	31.1	21.8	72	59.0	41.3
5	4.1	2.9	39	31.9	22.4	73	59.8	41.9
6	4.9	3.4	40	32.8	22.9	74	60.6	42.5
7	5.7	4.0	41	33.6	23.5	75	61.5	43.0
8	6.6	4.6	42	34.4	24.1	76	62.3	43.6
9	7.4	5.2	43	35.2	24.6	77	63.1	44.2
10	8.2	5.7	44	36.0	25.2	78	63.9	44.8
11	9.0	6.3	45	36.8	25.8	79	64.7	45.3
12	9.8	6.9	46	37.7	26.4	80	65.5	45.9
13	10.6	7.5	47	38.5	27.0	81	66.4	46.5
14	11.5	8.0	48	39.3	27.5	82	67.2	47.0
15	12.3	8.6	49	40.1	28.1	83	68.0	47.6
16	13.1	9.2	50	41.0	28.7	84	68.8	48.2
17	13.9	9.8	51	41.8	29.2	85	69.6	48.8
18	14.7	10.3	52	42.6	29.8	86	70.5	49.3
19	15.6	10.9	53	43.4	30.4	87	71.3	49.9
20	16.4	11.5	54	44.2	31.0	88	72.1	50.5
21	17.2	12.0	55	45.1	31.5	89	72.9	51.1
22	18.0	12.6	56	45.9	32.1	90	73.7	51.6
23	18.8	13.2	57	46.7	32.7	91	74.6	52.2
24	19.6	13.8	58	47.5	33.3	92	75.4	52.8
25	20.5	14.3	59	48.3	33.8	93	76.2	53.4
26	21.3	14.9	60	49.1	34.4	94	77.0	53.9
27	22.1	15.5	61	50.0	35.0	95	77.8	54.5
28	22.9	16.1	62	50.8	35.6	96	78.6	55.1
29	23.7	16.6	63	51.6	36.1	97	79.5	55.6
30	24.6	17.2	64	52.4	36.7	98	80.3	56.2
31	25.4	17.8	65	53.3	37.3	99	81.1	56.8
32	26.2	18.4	66	54.1	37.9	100	81.9	57.4
33	27.0	18.9	67	54.9	38.4	200	163.8	114.7
34	27.8	19.5	68	55.7	39.0	300	245.8	172.1
Diff.	Dep.	Lat.	Diff.	Dep.	Lat.	Diff.	Dep.	Lat.
	55 Deg.			55 Deg.			55 Deg.	



Diff.	36 Deg.		Diff.	36 Deg.		Diff.	36 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	.8	.6	35	28.3	20.6	69	55.8	40.6
2	1.6	1.2	36	29.1	21.1	70	56.6	41.1
3	2.4	1.8	37	29.9	21.7	71	57.4	41.7
4	3.2	2.3	38	30.7	22.3	72	58.2	42.3
5	4.0	2.9	39	31.5	22.9	73	59.0	42.9
6	4.8	3.5	40	32.4	23.5	74	59.9	43.5
7	5.7	4.1	41	33.2	24.1	75	60.7	44.1
8	6.5	4.7	42	34.0	24.7	76	61.5	44.7
9	7.2	5.3	43	34.8	25.3	77	62.3	45.3
10	8.1	5.9	44	35.6	25.8	78	63.1	45.8
11	8.9	6.5	45	36.4	26.4	79	63.9	46.4
12	9.7	7.0	46	37.2	27.0	80	64.7	47.0
13	10.5	7.6	47	38.0	27.6	81	65.5	47.6
14	11.3	8.2	48	38.8	28.2	82	66.3	48.2
15	12.1	8.8	49	39.6	28.8	83	67.2	48.8
16	12.9	9.4	50	40.4	29.4	84	68.1	49.4
17	13.8	10.0	51	41.3	30.0	85	68.0	50.0
18	14.6	10.6	52	42.1	30.6	86	69.8	50.6
19	15.4	11.2	53	42.9	31.1	87	70.6	51.1
20	16.2	11.8	54	43.7	31.7	88	71.4	51.7
21	17.0	12.3	55	44.5	32.3	89	72.0	52.3
22	17.8	12.9	56	45.3	32.9	90	72.8	52.9
23	18.6	13.5	57	46.1	33.5	91	73.6	53.5
24	19.4	14.1	58	46.9	34.1	92	74.4	54.1
25	20.2	14.7	59	47.7	34.7	93	75.2	54.7
26	21.0	15.3	60	48.5	35.3	94	76.0	55.3
27	21.8	15.9	61	49.3	35.8	95	76.8	55.8
28	22.6	16.4	62	50.2	36.4	96	77.7	56.4
29	23.5	17.6	63	51.0	37.0	97	78.5	57.0
30	24.3	17.0	64	51.8	37.6	98	79.3	57.6
31	25.1	18.2	65	52.6	38.2	99	80.1	58.2
32	25.9	18.8	66	53.4	38.8	100	80.9	58.8
33	26.7	19.4	67	54.2	39.4	200	161.8	117.6
34	27.5	20.0	68	55.0	40.0	300	242.7	176.3
Diff.	Dep.	Lat.	Diff.	Dep.	Lat.	Diff.	Dep.	Lat.
	54 Deg.			54 Deg.			54 Deg.	



Diff.	37 Deg.		Diff.	37 Deg.		Diff.	37 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	.8	.6	35	27.9	21.0	69	55.1	41.5
2	1.6	1.2	36	28.7	21.6	70	55.9	42.1
3	2.4	1.8	37	29.5	22.2	71	56.7	42.7
4	3.2	2.4	38	30.3	22.8	72	57.5	43.3
5	4.0	3.0	39	31.1	23.4	73	58.3	43.9
6	4.8	3.6	40	31.9	24.1	74	59.1	44.5
7	5.6	4.2	41	32.7	24.7	75	59.9	45.1
8	6.4	4.8	42	33.5	25.3	76	60.7	45.7
9	7.2	5.4	43	34.3	25.9	77	61.5	46.3
10	8.0	6.0	44	35.1	26.5	78	62.3	46.9
11	8.8	6.6	45	35.9	27.1	79	63.1	47.5
12	9.6	7.2	46	36.7	27.7	80	63.9	48.1
13	10.4	7.8	47	37.5	28.3	81	64.7	48.7
14	11.2	8.4	48	38.3	28.9	82	65.5	49.3
15	12.0	9.0	49	39.1	29.5	83	66.3	50.0
16	12.8	9.6	50	39.9	30.1	84	67.1	50.6
17	13.6	10.2	51	40.7	30.7	85	67.9	51.2
18	14.4	10.8	52	41.5	31.3	86	68.7	51.8
19	15.2	11.4	53	42.3	31.9	87	69.5	52.4
20	16.0	12.0	54	43.1	32.5	88	70.3	53.0
21	16.8	12.6	55	43.9	33.1	89	71.1	53.6
22	17.6	13.2	56	44.7	33.7	90	71.9	54.2
23	18.4	13.8	57	45.5	34.3	91	72.7	54.8
24	19.2	14.4	58	46.3	34.9	92	73.5	55.4
25	20.0	15.0	59	47.1	35.5	93	74.3	56.0
26	20.8	15.6	60	47.9	36.1	94	75.1	56.6
27	21.6	16.2	61	48.7	36.7	95	75.9	57.2
28	22.4	16.8	62	49.5	37.3	96	76.7	57.8
29	23.2	17.4	63	50.3	37.9	97	77.5	58.4
30	24.0	18.0	64	51.1	38.5	98	78.3	59.0
31	24.8	18.6	65	51.9	39.1	99	79.1	59.6
32	25.6	19.2	66	52.7	39.7	100	79.9	60.2
33	26.4	19.8	67	53.5	40.3	200	159.7	120.4
34	27.1	20.4	68	54.3	40.9	300	239.6	180.5
Diff.	Dep.	Lat.	Diff.	Dep.	Lat.	Diff.	Dep.	Lat.
	53 Deg.			53 Deg.			53 Deg.	



Diff.	38 Deg.		Diff.	38 Deg.		Diff.	38 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	.8	.6	35	27.6	21.6	69	54.4	42.5
2	1.6	1.2	36	28.4	22.2	70	55.2	43.1
3	2.4	1.8	37	29.2	22.8	71	55.9	43.7
4	3.1	2.5	38	29.9	23.4	72	56.7	44.3
5	3.9	3.1	39	30.7	24.0	73	57.5	45.0
6	4.7	3.7	40	31.5	24.6	74	58.3	45.6
7	5.5	4.3	41	32.3	25.2	75	59.1	46.2
8	6.3	4.9	42	33.1	25.9	76	59.9	46.8
9	7.1	5.5	43	33.9	26.5	77	60.7	47.4
10	7.9	6.2	44	34.7	27.1	78	61.5	48.0
11	8.7	6.8	45	35.5	27.7	79	62.2	48.6
12	9.5	7.4	46	36.2	28.3	80	63.0	49.3
13	10.2	8.0	47	37.0	28.9	81	63.8	49.9
14	11.0	8.6	48	37.8	29.6	82	64.6	50.5
15	11.8	9.2	49	38.6	30.2	83	65.4	51.1
16	12.6	9.9	50	39.4	30.8	84	66.2	51.7
17	13.4	10.5	51	40.2	31.4	85	67.0	52.3
18	14.2	11.1	52	41.0	32.0	86	67.8	53.0
19	15.0	11.3	53	41.8	32.6	87	68.6	53.6
20	15.8	12.7	54	42.6	33.2	88	69.3	54.2
21	16.6	12.9	55	43.3	33.9	89	70.1	54.8
22	17.3	13.6	56	44.1	34.5	90	70.9	55.4
23	18.1	14.2	57	44.9	35.1	91	71.7	56.0
24	18.9	14.8	58	45.7	35.7	92	72.5	56.6
25	19.7	15.4	59	46.5	36.3	93	73.3	57.3
26	20.5	16.0	60	47.3	36.9	94	74.1	57.9
27	21.3	16.6	61	48.1	37.6	95	74.9	58.5
28	22.1	17.2	62	48.9	38.2	96	75.6	59.1
29	22.9	17.9	63	49.6	38.8	97	76.4	59.7
30	23.7	18.5	64	50.4	39.4	98	77.2	60.3
31	24.4	19.1	65	51.2	40.0	99	78.0	61.0
32	25.2	19.7	66	52.0	40.6	100	78.8	61.6
33	26.0	20.3	67	52.8	41.2	200	157.6	123.1
34	26.8	20.9	68	53.6	41.9	300	236.4	184.7
Diff.	Dep.	Lat.	Diff.	Dep.	Lat.	Diff.	Dep.	Lat.
	52 Deg.			52 Deg.			52 Deg.	



Diff.	39 Deg.		Diff.	39 Deg.		Diff.	39 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	.8	.6	35	27.2	22.0	69	53.6	43.4
2	1.6	1.3	36	28.0	22.6	70	54.4	44.0
3	2.3	1.9	37	28.7	23.3	71	55.2	44.7
4	3.1	2.5	38	29.5	23.9	72	55.9	45.3
5	3.9	3.1	39	30.3	24.5	73	56.7	45.9
6	4.7	3.8	40	31.1	25.2	74	57.5	46.6
7	5.4	4.4	41	31.8	25.8	75	58.3	47.2
8	6.2	5.0	42	32.6	26.4	76	59.1	47.8
9	7.0	5.7	43	33.4	27.1	77	59.8	48.5
10	7.8	6.3	44	34.2	27.7	78	60.6	49.1
11	8.5	6.9	45	35.0	28.3	79	61.4	49.7
12	9.3	7.5	46	35.7	28.9	80	62.2	50.3
13	10.1	8.2	47	36.5	29.6	81	62.9	51.0
14	10.9	8.8	48	37.3	30.2	82	63.7	51.6
15	11.6	9.4	49	38.1	30.8	83	64.5	52.2
16	12.4	10.1	50	38.8	31.5	84	65.3	52.9
17	13.2	10.7	51	39.6	32.1	85	66.1	53.5
18	14.0	11.3	52	40.4	32.7	86	66.8	54.1
19	14.8	11.9	53	41.2	33.4	87	67.6	54.7
20	15.5	12.6	54	41.9	34.0	88	68.4	55.4
21	16.3	13.2	55	42.7	34.6	89	69.2	56.0
22	17.1	13.8	56	43.5	35.2	90	69.9	56.6
23	17.9	14.5	57	44.3	35.9	91	70.7	57.3
24	18.6	15.1	58	45.1	36.5	92	71.5	57.9
25	19.4	15.7	59	45.8	37.1	93	72.3	58.5
26	20.2	16.4	60	46.6	37.8	94	73.1	59.1
27	21.0	17.0	61	47.4	38.4	95	73.8	59.8
28	21.7	17.6	62	48.2	39.0	96	74.6	60.4
29	22.5	18.2	63	48.9	39.6	97	75.4	61.0
30	23.3	18.9	64	49.7	40.3	98	76.2	61.7
31	24.1	19.5	65	50.5	40.9	99	76.9	62.3
32	24.9	20.1	66	51.3	41.5	100	77.7	62.9
33	25.6	20.8	67	52.1	42.2	200	155.4	125.9
34	26.4	21.4	68	52.8	42.8	300	233.1	188.8
Diff.	Dep.	Lat.	Diff.	Dep.	Lat.	Diff.	Dep.	Lat.
	51 Deg.			51 Deg.			51 Deg.	



Diff.	40 Deg.		Diff.	40 Deg.		Diff.	40 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	.8	.6	35	26.8	22.5	69	52.9	44.3
2	1.5	1.3	36	27.6	23.1	70	53.6	45.0
3	2.3	1.9	37	28.3	23.8	71	54.4	45.6
4	3.1	2.6	38	29.1	24.4	72	55.2	46.3
5	3.8	3.2	39	29.9	25.1	73	55.9	46.9
6	4.6	3.8	40	30.6	25.7	74	56.7	47.6
7	5.4	4.5	41	31.4	26.3	75	57.4	48.2
8	6.1	5.1	42	32.2	27.0	76	58.2	48.5
9	6.9	5.8	43	32.9	27.6	77	59.0	49.5
10	7.7	6.4	44	33.7	28.3	78	59.7	50.1
11	8.4	7.1	45	34.5	28.9	79	60.5	50.8
12	9.2	7.7	46	35.2	29.6	80	61.3	51.4
13	10.0	8.3	47	36.0	30.2	81	62.0	52.1
14	10.7	9.0	48	36.8	30.9	82	62.8	52.7
15	11.5	9.6	49	37.5	31.5	83	63.6	53.3
16	12.3	10.3	50	38.3	32.1	84	64.3	54.0
17	13.0	10.9	51	39.1	32.8	85	65.1	54.6
18	13.8	11.6	52	39.8	33.4	86	65.9	55.3
19	14.6	12.2	53	40.6	34.1	87	66.6	55.9
20	15.3	12.9	54	41.4	34.7	88	67.4	56.6
21	16.1	13.5	55	42.1	35.3	89	68.2	57.2
22	16.9	14.1	56	42.9	36.0	90	68.9	57.9
23	17.6	14.8	57	43.7	36.6	91	69.7	58.5
24	18.4	15.4	58	44.4	37.3	92	70.5	59.1
25	19.2	16.1	59	45.2	37.9	93	71.2	59.8
26	19.9	16.7	60	46.0	38.6	94	72.0	60.4
27	20.7	17.3	61	46.7	39.2	95	72.7	61.1
28	21.4	18.0	62	47.5	39.9	96	73.5	61.7
29	22.2	18.6	63	48.3	40.5	97	74.3	62.3
30	23.0	19.3	64	49.0	41.1	98	75.1	63.0
31	23.7	19.9	65	49.8	41.8	99	75.8	63.6
32	24.5	20.6	66	50.6	42.4	100	76.6	64.3
33	25.3	21.2	67	51.3	43.1	200	153.2	128.6
34	26.0	21.9	68	52.1	43.7	300	229.8	192.8
Diff.	Dep.	Lat.	Diff.	Dep.	Lat.	Diff.	Dep.	Lat.
	50 Deg.			50 Deg.			50 Deg.	



Diff.	41 Deg.		Diff.	41 Deg.		Diff.	41 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	.8	.7	35	26.4	22.9	69	52.1	45.2
2	1.5	1.3	36	27.2	23.6	70	52.8	45.9
3	2.3	2.0	37	27.9	24.3	71	53.6	46.6
4	3.0	2.6	38	28.7	24.9	72	54.3	47.2
5	3.8	3.3	39	29.4	25.6	73	55.1	47.8
6	4.5	3.9	40	30.2	26.2	74	55.8	48.5
7	5.3	4.6	41	30.9	26.9	75	56.6	49.2
8	6.0	5.2	42	31.7	27.5	76	57.4	49.8
9	6.8	5.9	43	32.4	28.2	77	58.1	50.5
10	7.5	6.6	44	33.2	28.9	78	58.9	51.2
11	8.3	7.2	45	33.9	29.5	79	59.6	51.8
12	9.1	7.9	46	34.7	30.2	80	60.4	52.5
13	9.8	8.5	47	35.4	30.8	81	61.1	53.1
14	10.6	9.2	48	36.2	31.5	82	61.9	53.8
15	11.3	9.8	49	36.9	32.1	83	62.6	54.4
16	12.1	10.5	50	37.7	32.8	84	63.4	55.1
17	12.8	11.2	51	38.5	33.4	85	64.1	55.7
18	13.6	11.8	52	39.2	34.1	86	64.9	56.4
19	14.3	12.5	53	40.0	34.8	87	65.6	57.1
20	15.1	13.1	54	40.7	35.4	88	66.4	57.7
21	15.9	13.8	55	41.5	36.1	89	67.1	58.4
22	16.6	14.4	56	42.2	36.7	90	67.9	59.0
23	17.4	15.1	57	43.0	37.4	91	68.7	59.7
24	18.1	15.7	58	43.8	38.0	92	69.4	60.3
25	18.9	16.4	59	44.5	38.7	93	70.2	61.0
26	19.6	17.1	60	45.3	39.4	94	70.9	61.6
27	20.4	17.7	61	46.0	40.0	95	71.7	62.3
28	21.1	18.4	62	46.8	40.7	96	72.4	62.9
29	21.9	19.0	63	47.5	41.3	97	73.2	63.6
30	22.6	19.7	64	48.3	42.0	98	73.9	64.3
31	23.4	20.3	65	49.0	42.6	99	74.7	64.9
32	24.1	21.0	66	49.8	43.3	100	75.5	65.6
33	24.9	21.6	67	50.6	43.9	200	150.9	131.2
34	25.7	22.3	68	51.3	44.6	300	226.4	196.8
Diff.	Dep.	Lat.	Diff.	Dep.	Lat.	Diff.	Dep.	Lat.
	49 Deg.			49 Deg.			49 Deg.	



42 Deg.			42 Deg.			42 Deg.		
Dif.	Lat.	Dep.	Dif.	Lat.	Dep.	Dif.	Lat.	Dep.
1	.7	.7	35	26.0	23.4	69	51.3	46.2
2	1.5	1.3	36	26.7	24.1	70	52.0	46.8
3	2.2	2.0	37	27.5	24.7	71	52.7	47.5
4	3.0	2.7	38	28.2	25.4	72	53.5	48.2
5	3.7	3.3	39	29.0	26.1	73	54.2	48.8
6	4.4	4.0	40	29.7	26.8	74	55.0	49.5
7	5.2	4.7	41	30.4	27.4	75	55.7	50.2
8	5.9	5.3	42	31.2	28.1	76	56.4	50.9
9	6.7	6.0	43	31.9	28.7	77	57.2	51.5
10	7.4	6.7	44	32.7	29.4	78	57.9	52.2
11	8.2	7.3	45	33.4	30.1	79	58.7	52.9
12	8.9	8.0	46	34.2	30.8	80	59.4	53.5
13	9.7	8.7	47	34.9	31.4	81	60.2	54.2
14	10.4	9.3	48	35.7	32.1	82	60.9	54.9
15	11.1	10.0	49	36.4	32.8	83	61.7	55.5
16	11.9	10.7	50	37.2	33.5	84	62.4	56.2
17	12.6	11.3	51	37.9	34.1	85	63.2	56.9
18	13.4	12.0	52	38.6	34.8	86	63.9	57.5
19	14.1	12.7	53	39.4	35.4	87	64.7	58.2
20	14.9	13.4	54	40.1	36.1	88	65.4	58.9
21	15.6	14.0	55	40.9	36.8	89	66.1	59.5
22	16.3	14.7	56	41.6	37.5	90	66.9	60.2
23	17.1	15.4	57	42.3	38.1	91	67.6	60.9
24	17.8	16.0	58	43.1	38.8	92	68.4	61.5
25	18.6	16.7	59	43.8	39.5	93	69.1	62.2
26	19.3	17.4	60	44.6	40.1	94	69.9	62.9
27	20.1	18.0	61	45.3	40.8	95	70.6	63.5
28	20.8	18.7	62	46.1	41.5	96	71.3	64.2
29	21.5	19.4	63	46.8	42.1	97	72.1	64.9
30	22.3	20.1	64	47.5	42.8	98	72.8	65.5
31	23.0	20.7	65	48.3	43.5	99	73.6	66.2
32	23.8	21.4	66	49.0	44.2	100	74.3	66.9
33	24.5	22.1	67	49.8	44.8	200	148.6	133.8
34	25.3	22.7	68	50.5	45.5	300	222.8	200.7
Dif.	Dep.	Lat.	Dif.	Dep.	Lat.	Dif.	Dep.	Lat.
	48 Deg.			48 Deg.			48 Deg.	



Diff.	43 Deg.	
	Lat.	Dep.
1	.7	.7
2	1.5	1.4
3	2.2	2.0
4	2.9	2.7
5	3.6	3.4
6	4.4	4.1
7	5.1	4.8
8	5.8	5.4
9	6.6	6.1
10	7.3	6.8
11	8.0	7.5
12	8.8	8.2
13	9.5	8.9
14	10.2	9.5
15	11.0	10.2
16	11.7	10.9
17	12.4	11.6
18	13.2	12.3
19	13.9	13.0
20	14.6	13.6
21	15.3	14.3
22	16.1	15.0
23	16.8	15.7
24	17.5	16.4
25	18.3	17.0
26	19.0	17.7
27	19.7	18.4
28	20.5	19.1
29	21.2	19.8
30	21.9	20.5
31	22.7	21.1
32	23.4	21.8
33	24.1	22.5
34	24.8	23.2
Diff.	Dep.	Lat.
	47 Deg.	

Diff.	43 Deg.	
	Lat.	Dep.
35	25.6	23.9
36	26.3	24.5
37	27.0	25.2
38	27.8	25.9
39	28.5	26.6
40	29.2	27.3
41	30.0	28.0
42	30.7	28.6
43	31.4	29.3
44	32.2	30.0
45	32.9	30.7
46	33.6	31.4
47	34.4	32.0
48	35.1	32.7
49	35.8	33.4
50	36.6	34.1
51	37.3	34.8
52	38.0	35.5
53	38.8	36.1
54	39.5	36.8
55	40.2	37.5
56	40.9	38.2
57	41.7	38.9
58	42.4	39.5
59	43.1	40.2
60	43.9	40.9
61	44.6	41.6
62	45.3	42.3
63	46.1	43.0
64	46.8	43.6
65	47.5	44.3
66	48.3	45.0
67	49.0	45.7
68	49.7	46.4
Diff.	Dep.	Lat.
	47 Deg.	

Diff.	43 Deg.	
	Lat.	Dep.
69	50.5	47.0
70	51.2	47.7
71	51.9	48.4
72	52.6	49.1
73	53.4	49.8
74	54.1	50.5
75	54.8	51.1
76	55.6	51.8
77	56.3	52.5
78	57.0	53.2
79	57.8	53.9
80	58.5	54.6
81	59.2	55.2
82	60.0	55.9
83	60.7	56.6
84	61.4	57.3
85	62.2	58.0
86	62.9	58.7
87	63.6	59.3
88	64.3	60.0
89	65.1	60.7
90	65.8	61.4
91	66.5	62.1
92	67.3	62.7
93	68.0	63.4
94	68.7	64.1
95	69.5	64.8
96	70.2	65.5
97	70.9	66.1
98	71.7	66.8
99	72.4	67.5
100	73.1	68.2
200	146.3	136.4
300	219.4	204.6
Diff.	Dep.	Lat.
	47 Deg.	



Diff.	44 Deg.		Diff.	44 Deg.		Diff.	44 Deg.	
	Lat.	Dep.		Lat.	Dep.		Lat.	Dep.
1	.7	.7	35	25.2	24.3	69	49.6	47.9
2	1.4	1.4	36	25.9	25.0	70	50.3	48.6
3	2.2	2.1	37	26.6	25.7	71	51.1	49.3
4	2.9	2.8	38	27.3	26.4	72	51.8	50.0
5	3.6	3.5	39	28.0	27.1	73	52.5	50.7
6	4.3	4.2	40	28.8	27.8	74	53.2	51.4
7	5.0	4.9	41	29.5	28.5	75	53.9	52.1
8	5.8	5.6	42	30.2	29.2	76	54.7	52.8
9	6.5	6.2	43	30.9	29.9	77	55.4	53.5
10	7.2	6.9	44	31.6	30.6	78	56.1	54.2
11	7.9	7.6	45	32.4	31.3	79	56.8	54.9
12	8.6	8.3	46	33.1	32.0	80	57.5	55.6
13	9.3	9.0	47	33.8	32.7	81	58.3	56.3
14	10.1	9.7	48	34.5	33.4	82	59.0	57.0
15	10.8	10.4	49	35.2	34.0	83	59.7	57.7
16	11.5	11.1	50	36.0	34.7	84	60.4	58.4
17	12.2	11.8	51	36.7	35.4	85	61.1	59.0
18	12.9	12.5	52	37.4	36.1	86	61.9	59.7
19	13.7	13.2	53	38.1	36.8	87	62.6	60.4
20	14.4	13.9	54	38.8	37.5	88	63.3	61.1
21	15.1	14.6	55	39.6	38.2	89	64.0	61.8
22	15.8	15.3	56	40.3	38.9	90	64.7	62.5
23	16.5	16.0	57	41.0	39.6	91	65.5	63.2
24	17.3	16.7	58	41.7	40.3	92	66.2	63.9
25	18.0	17.4	59	42.4	41.0	93	66.9	64.6
26	18.7	18.1	60	43.2	41.7	94	67.6	65.3
27	19.4	18.8	61	43.9	42.4	95	68.3	66.0
28	20.1	19.5	62	44.6	43.1	96	69.0	66.7
29	20.9	20.1	63	45.3	43.8	97	69.8	67.4
30	21.6	20.8	64	46.0	44.5	98	70.5	68.1
31	22.3	21.5	65	46.8	45.2	99	71.2	68.8
32	23.0	22.2	66	47.5	45.8	100	71.9	69.5
33	23.7	22.9	67	48.2	46.5	200	143.9	138.9
34	24.5	23.6	68	48.9	47.2	300	215.8	208.4
Diff.	Dep.	Lat.	Diff.	Dep.	Lat.	Diff.	Dep.	Lat.
	46 Deg.			46 Deg.			46 Deg.	



Diff.	45 Deg.	
	Lat.	Dep.
1	.7	.7
2	1.4	1.4
3	2.1	2.1
4	2.8	2.8
5	3.5	3.5
6	4.2	4.2
7	4.9	4.9
8	5.6	5.6
9	6.4	6.4
10	7.1	7.1
11	7.8	7.8
12	8.5	8.5
13	9.2	9.2
14	9.9	9.9
15	10.6	10.6
16	11.3	11.3
17	12.0	12.0
18	12.7	12.7
19	13.4	13.4
20	14.1	14.1
21	14.8	14.8
22	15.5	15.5
23	16.3	16.3
24	17.0	17.0
25	17.7	17.7
26	18.4	18.4
27	19.1	19.1
28	19.8	19.8
29	20.5	20.5
30	21.2	21.2
31	21.9	21.9
32	22.6	22.6
33	23.3	23.3
34	24.0	24.0
	Dep.	Lat.
Diff.	45 Deg.	

Diff.	45 Deg.	
	Lat.	Dep.
35	24.7	24.7
36	25.4	25.4
37	26.1	26.1
38	26.8	26.8
39	27.5	27.5
40	28.3	28.3
41	29.0	29.0
42	29.7	29.7
43	30.4	30.4
44	31.1	31.1
45	31.8	31.8
46	32.5	32.5
47	33.2	33.2
48	33.9	33.9
49	34.6	34.6
50	35.3	35.3
51	36.0	36.0
52	36.7	36.7
53	37.5	37.5
54	38.2	38.2
55	38.9	38.9
56	39.6	39.6
57	40.3	40.3
58	41.0	41.0
59	41.7	41.7
60	42.4	42.4
61	43.1	43.1
62	43.8	43.8
63	44.5	44.5
64	45.2	45.2
65	45.9	45.9
66	46.6	46.6
67	47.4	47.4
68	48.1	48.1
	Dep.	Lat.
Diff.	45 Deg.	

Diff.	45 Deg.	
	Lat.	Dep.
69	48.8	48.8
70	49.5	49.5
71	50.2	50.2
72	50.9	50.9
73	51.6	51.6
74	52.3	52.3
75	53.0	53.0
76	53.7	53.7
77	54.4	54.4
78	55.1	55.1
79	55.8	55.8
80	56.6	56.6
81	57.3	57.3
82	58.0	58.0
83	58.7	58.7
84	59.4	59.4
85	60.1	60.1
86	60.8	60.8
87	61.5	61.5
88	62.2	62.2
89	62.9	62.9
90	63.6	63.6
91	64.3	64.3
92	65.0	65.0
93	65.7	65.7
94	66.5	66.5
95	67.2	67.2
96	67.8	67.8
97	68.6	68.6
98	69.3	69.3
99	70.0	70.0
100	70.7	70.7
200	141.4	141.4
300	212.1	212.1
	Dep.	Lat.
Diff.	45 Deg.	



Now for the form of setting down a Reckoning, although he which is accustomed to keep it in this manner, may happily by use and practice discern how to order it in a better way than I can presently prescribe or think upon, because he hath occasion often to consider it in every particular; yet in the mean time I conceive it will be fit to have a Book in *Folio*, that is, two Leaves to a sheet of Paper, and to keep the left side of your Book void, that you may write therein all such Occurents, as you shall think requisite. As namely, the Winds, and the Points of the Compass upon which your Ship lies; and what allowance you make for Leeward-way when you sail by a Wind; the number of Glasses or Hours, or how many Knots or Miles in each Hour; also the Latitudes, which you find by Observation of the Meridian Altitude of the Stars, and what else you shall think remarkable. But before all this, the Title of the Voyage in these, or the like words;

*The Journal of our Voyage, intended by God's assistance from S. I. in the Latitude of 32 deg. 25 min. to the Coast of England, &c.*

The Right-hand Pages, or the right side of your Book throughout, may by Lines be divided into twelve Columns, as in the Example following doth appear. In the first Column may be expressed the Day, in the second the Month, or at least once in the top of the Page; likewise in the same second Column, being large enough, may be set down the Latitudes, which you find by the Meridian Altitudes of the Sun at such times as you make Observation. In the third Column the Course (the Leeward-way, if there be any Leeing allowed.) In the fourth, the Variation of the Needle. In the fifth (having made allowance for the Variation) set down the Angle of your Rhomb with the Meridian. In the sixth Column, set down the distance in Miles run upon that Rhomb. In the seventh, eighth, ninth and tenth Columns, the Northing or Southing, Easting or Westing thereto answering, as you shall find it by your Table. In the eleventh, your Latitudes by Dead-Reckoning. And lastly, in the twelfth Column, you may at such times as you think fittest, set down your Longitude from the place from which you first departed, or the difference of Longitude from place to place.

*Days.*



Days.	Latit. by observat.	Course.	Variation.	deg. from the merid.	dist. in miles.	North	South.	East.	West.	Lat. by dead r.	Longi- tude.
20	February.	N. E. by E.	8 deg. West.	ne 48 d.	miles 78	522		579		deg. 33.17	
21	Latitude 34 d. 25'	N. E. by E.	8 deg. West.	ne 48 d.	100	669		743		34.24	
21	34 d. 25'			Sum is		1191		1322		34.24	02.38

22		e. n. e. $\frac{1}{2}$ poin.	8 deg. West.	ne 54 d.	100 56	588 329		809 453		35.56	
23	Latitude 37 d. 46'	e. n. e. $\frac{1}{2}$ nor.	8 deg. West.	ne 54 d.	100 78	588 458		809 631		37.40	
24	Latitude 39 d. 36'	e. n. e. $\frac{1}{2}$ nor.	8 deg. West.	ne 54 d.	100 84	588 494		809 679		39.28	
				Sum is		3045		4190			
				The Correction by Observat. is 80				110		08	
24	39.36				3125			4300		39.36	11.36

25	February.	e. n. e.	8 deg. West.	ne 59 $\frac{1}{2}$	100 76	507 385		861 655		41.05	
26		e. n. e.	8 deg. West.	ne 59 $\frac{1}{2}$	100 80	507 412		861 686		42.37	
27	Latitude 43 d. 55'	e. n. e.	7 $\frac{1}{2}$ deg. West.	ne 60 d.	100 84	500 420		866 728		44.09	
				Sum is		2731		4657			
				Correction			140		245	14	
27	L. 43.55					2591		4412		43.55	21.28

28	February.	e. n. e. $\frac{1}{2}$ e.	6 deg. West.	ne 67 d.	100 51	391 199		921 469		44.54	
29		e. n. e. $\frac{1}{2}$ e.	5 deg. West.	ne 68 d.	100 81	375 304		927 751		46.02	
1	March.	e. n. e. $\frac{1}{2}$ e.	4 deg. West.	ne 69 d.	100 66	358 237		934 616		47.02	
2	La. 48.4.	e. n. e. $\frac{1}{2}$ e.	2 deg. West.	ne 71 d.	100 78	326 254		946 737		48.00	
2	La. 48.4.			Sum is		2444		6301		48.00	36.38



Days.	Latit. by Observat.	Course.	Vari- ation.	deg. from the merid.	dist. in m.	North.	South.	East.	West.	Latit. by dead rec.	Longi- tude.
3	March.	e. n. e.	0 deg.	n. e. 73 d.	100	292		956		48. 44.	
		$\frac{1}{2}$ e.	West.		52	152		497			
4		e. n. e.	2 deg.	n. e. 75 d.	100	259		966		49. 28.	
		$\frac{1}{2}$ e.	East.		68	176		657			
5	Latitude 49 d. 58'	e. n. e.	3 deg.	n. e. 76 d.	98	237		951		49. 52.	
		$\frac{1}{2}$ e.	East.								
5	L. 49. 58			Sum is		1116		4027		49. 52.	46. 52

5	8 Hours.	n by e	4 deg.	n e 21 d.	18	168		64		50. 09.	
		$\frac{1}{2}$ e.	East.								
6		South by e.	4 deg.	s e 7 de.	34		337	41		49. 35.	
			East.								
6	16 Hour.	n. by east.	4 deg.	n e 15 d.	36	348		93		50. 10.	
			East.								
7		s. e. by east.	4 deg.	s e 52 d.	20		123	158		49. 58.	
			East.								
8	Latitude 50 d. 4'	East.	4 deg.	s e 86 d.	96		67	958		49. 51.	
			East.								
	The Cur- rent set. by estim.	East Nort. East.		n e 67 $\frac{1}{2}$	60	230		554		50. 14.	
				Sum is		219		1868			
				Correction			100			10'	
8	L. 50 d 4					119		1868		50. 04.	51. 43

9		East $\frac{1}{2}$ po. n.	6 deg.	s e 89 $\frac{1}{2}$	70		60	700		49. 58.	
			East.								
10		east $\frac{1}{2}$ po. n.	6 deg.	s e 89 $\frac{1}{2}$	52		41	520		49. 54.	
			East.								
10	March.			Sum is			101	1220		49. 54.	54. 53

Here the  
Lizard  
bears

N. by E.

13

O

For



For an Example, we may frame a Reckoning between the two places before-mentioned; namely, from *Summer-Islands* to the *Lizard*, whose distance in the Rhomb we have before supposed to be 3299 Miles, as some *Charts* make it, and consequently their difference of Longitude 70 deg. I would not be understood as if I affirmed it to be so much, for I suppose it is less. I was there indeed about 20 Years past, and surveyed it, and then kept a Reckoning both outwards and homewards, but I have lost those Reckonings long since, and forgotten what they were, and in this case it matters not: for whether the Supposition be near the truth or not, it serves sufficiently to exemplify the Rule, that being the end for which it is used. But if their distance be 3299 such Miles as contain only 1000 Paces in a Mile, the same being reckoned in such Miles, as we have before mentioned, namely, in such whereof 60 make a degree of a great Circle, which, as we find, contains 6120 Feet in a Mile, their distance will be little more than 2695 Miles; and consequently, the difference of Longitude little more than  $55\frac{1}{2}$  degrees.

Let us therefore suppose the difference of Longitude between those two places to be 55 degrees, and their Latitudes to be the same as before; namely, of the one 32 deg. 25 min. and of the other 50 degrees. And let the Courses, Distances, and other Observations from *Summer-Islands* to the *Lizard* be such as before is shewed.

The first entrance in this Journal (which is the 20th day of *February*) is thus to be understood; namely, that from the time of setting Sail (which we suppose to be the 19th of *February*) till the 20th day at Noon, the Ship lies away, and makes her way good upon the North-East and by East Point of the Compass; but the Variation being 8 degrees to the Westwards (as in the fourth Column appears) the Rhomb upon which she hath run is from the North to the Eastwards only 48 degrees, as is expressed in the fifth Column (it is indeed  $48\frac{1}{4}$  deg. but the  $\frac{1}{4}$  deg. we omit, as for the other Circumstances not to be regarded: ) upon this Rhomb she runs 78 miles, as in the sixth Column appears; and answerable thereto I find in the Table before going the Northing to be  $52\frac{9}{10}$  miles, and the Easting  $57\frac{9}{10}$ , as here in the seventh and ninth Columns is expressed by these Numbers 522 and 579 (for the first Figure towards the Right-hand signifieth the tenth part of a Mile, the rest Miles. ) Hence then the Northing being 52 Miles, if that be added to the Latitude from which it is reckoned, namely, 32 deg. 25 min. it makes the Latitude here to be 33 deg. 17 min. as in the eleventh Column appears. In like sort, the second entrance



entrance being the 21 of *February*, sheweth that from the 20 day at Noon to the 21, she made her way good upon the North-East by East Point of the Compass; but the Variation being 8 degrees Westerly the Angle of the Rhomb, with the true Meridian, was from the North to the Eastwards 48 degrees; and so sailing 100 miles, the Northing is  $69\frac{1}{2}$  miles, and the Easting  $74\frac{1}{2}$  miles; so that the Latitude is now 34 deg. 24 min. and the like is to be understood of all the rest.

Touching the Longitude expressed in the last Column, although all a Reckoning may be kept and set down without it, yet it is of very good use; and how to convert the Easting or Westing (that is, the miles expressed in the East and West Columns of your Journal) into degrees and minutes of Longitude, we will shew afterwards; as also how you may easily correct your Course, and give the true Course or Rhomb, allowing the Variation.

But first to proceed with this Journal. Observing the Meridian-Altitude of the Sun upon the 23d and 24th of *February*, I find that my Latitude upon the 24th is 39 deg. 36 min. whereas by Dead-Reckoning it is but 39 deg. 28 min. so the Difference is 8 more Northerly: But being we'll assured of the Latitude found by Observation, I correct the Dead-Reckoning thereby, which may be done by the Rule of Proportion, saying;

As the Sum of the North Column,	3125	Co. ar.	6.50515
to the Sum of the East Column,	4300		3.63347
So the foresaid Increase Northerly	80		1.90309
to the increase Easterly,	110		<u>2.04171</u>

That is, 11 miles; for the first place towards the right-hand is only for the 10 part of a mile.

The same may also sufficiently be found without the Rule of Proportion, by the foregoing Table, only for looking there under the Degree upon which I have sailed, namely, under 54 degrees for 8 miles, or 80 tenths of a mile; though I find not the same exactly, yet I find one which is near it, namely, 82, and against it in the next collateral Column 113, which is  $11\frac{1}{2}$  Miles (being too much by  $\frac{1}{2}$  of a Mile, because the other is too much by  $\frac{1}{2}$ ; ) I add therefore in the North Column of the Journal 8 Miles, and the East Column 11 Miles; and so whereas by dead reckoning, the Northing was but  $304\frac{1}{2}$  Miles, and the Easting 419 Miles; now having corrected it by Observation, the Northing is  $312\frac{1}{2}$  Miles, and Easting 430 Miles.

In the like sort, upon the 27th day, I should by dead Reckoning be



in the Latitude of 44 deg. 9 min. but by a clear and good Observation I find my self in the Latitude of 43 deg. and 55 min. that is, not so much Northerly by 14 min. therefore to correct it, I put in the South Column 14 Miles, or 140 Tenths, and seeing my Course was between the North and the East, and that I find my self to be less to the Northwards, that is, more to the Southwards than my Reckoning; therefore in probability I am also less to the Eastwards; that is, more to the Westwards than my Reckoning: but to find how much, I look in the foregoing Table for the Degree upon which I have sailed, being from the North part of the Meridian to the Eastwards 60 deg. and under 60 deg. I look for 14 Miles, or 140 tenths, and against it in the Column adjoyning I find 243, which I set down in my Journal in the West Column, and so subtracting the first from the North Column, the other from the East, I find that whereas by dead Reckoning I should be to the Northwards  $273 \frac{1}{10}$  Miles, and to the Eastwards  $46 \frac{7}{10}$ . Now having corrected it by Observation, I find that from the 24 day till this time I have run more Northerly than I was by  $259 \frac{1}{10}$  Miles, and more Easterly by  $441 \frac{2}{10}$  Miles.

But if your Course be near the East or West, it may suffice to correct it in Latitude only, as in the Example of the 8th of *March* appears; for in that case you cannot correct the Longitude, but from some further ground.

If there be any Current, you may note it, as it is done in that Example, following the 8th of *March*.

Now if you would set down this Reckoning upon the plain or common *Sea Chart*; First, if you desire to express every days Account, you may begin for the 20th of *February*, and make a prick in your Plot that may be from the place from which you set sail to the Northwards  $52 \frac{2}{10}$  Miles, and to the Eastwards  $57 \frac{9}{10}$ ; and so will this Point be distant from the place of your setting Sail 78 Miles N. E. and almost a quarter of a Point Easterly: then for the 21 day you may make another Prick, which may be from the form to the Northwards  $66 \frac{9}{10}$  Miles, and to the Eastwards  $74 \frac{3}{10}$  Miles, and so you may proceed with the rest. And thus you shall have a Prick on the Plot for every day more exactly set down, than could be done after the ordinary way by Course and Distance, or Course and Latitude; especially because in lining the Plot, there are not, nor cannot conveniently be drawn any more than the 32 Points of the Compass, viz, nor half points, quarters, or single degrees.

But if you desire not to set down every Days Reckoning (which is not



not necessary to be done) you may set down every of the Sums as they are corrected by Observation, after the self-same manner.

Or you may add together all those Sums, and so the Sum-Total of the North Column will be 1049 Miles, and of the East Column 2345 Miles: therefore in the Meridian of the place from which you depart, you may set down to the Northwards of that place 1049 Miles, which will fall in the Latitude of 49 deg. 51 min. almost, and from thence in that Parallel set down directly to the Eastwards 2345 Miles, and there make a Prick for the place where the Ship then is the tenth of *March*; and so is all this Reckoning set down at once.

If you keep Reckoning according to *Mercator*, it will be requisite sometimes to sum up your Reckonings past, namely, so often as you make any notable alteration in your Course; and so this Reckoning, or any other, may be set down, almost as easily on *Mercator's Chart*; the difference is, that here you must often alter your *Scale*, because the degrees of Latitude on this *Chart* are not equal, but grow greater and greater towards the Poles. Now then the distance between the two places is to be measured by that part of the Meridian, which is intercepted between the Latitudes of those two places: Or if both places lie in one and the same Latitude, their distance is measured by a degree, or other lesser quantity, taken about that Latitude; namely, half above, and half beneath.

Wherefore if you would make a Prick or Traverse-point in *Mercator's Chart*, answering to your Reckoning for the first day, namely, until the 20th of *February* at Noon; it appears by your Journal that Prick must be to the Northwards of the place from which you departed  $52\frac{2}{5}$  miles, and to the Eastwards  $57\frac{2}{5}$  miles.

Now instead of the North or South Columns, you may more conveniently use the last Column but one, shewing in what Latitude every Account doth fall; and so it appears that the Prick for the 20th of *February* must be in the Latitude of 33 deg. 17 min. Therefore in the Meridian of the *Summer Islands* from which you departed, make a Prick in the Latitude of 33 deg. 17 min. and from that Prick set down to the Eastwards in the same Latitude  $57\frac{2}{5}$  miles; and where it ends is the Traverse-Point answering to the 20th of *February*. The like may be done for the 21th day, and so for all the rest. This 58 miles may be taken in the Meridian from the Latitude of 32 deg. 22. min. to the Latitude of 33 deg. 20 min. Or otherwise, you may take the half of it, which is 29 miles, about the middle between both Latitudes, and double it.



But it is sufficient to set down the Sums of every two or three Days Accounts, or so often as there is any notable Difference in your Course. Thus if you would make a Prick in the *Chart*, answering to the 21th of *February*, being the first Sum; I see by the Journal, that it must be in the Latitude of 34 deg. 24 min. and to the Eastwards of the place from which I departed 132  $\frac{1}{2}$  miles. Therefore in the Meridian of the Place from whence I departed, I make a Prick in the Latitude of 34 deg. 24 min. and from that Prick I set in the same Latitude to the Eastwards 132  $\frac{1}{2}$  miles, and where it ends is the Traverse-Point answering to the 21th of *February*, being the first Sum. This 132 miles may be taken in the Meridian within, or a little without the two Latitudes, as before, namely, from 32 deg. 20 min. to 34 deg. 32 min.

In like sort, if you would make a Prick for the second Sum, being the 24th of *February*; it there appears that it must be in the Latitude of 39 deg. 36 min. and to the Eastwards of the Traverse-Point last before made 430 miles: therefore in the Meridian of that Traverse-Point I make a Prick in the Latitude of 39 deg. 36 min. and from that Prick I set to the Eastwards in the same Latitude 430 miles, and where that ends, is the Traverse-Point answering to the 24th Day; and the like is to be understood of all the rest.

Now this 430 miles may be taken several ways: for, first, if I take 1 degree about the middle of that part of the Meridian which is intercepted between the Latitudes of the two places (as from 36 deg. 30 min. to 37 deg. 30 min.) and that degree seven times taken, is 420 miles; then about the middle, namely, 37 deg. I take 10 minutes more, and so have 430 miles.

In like manner you may take 2 degrees, or 120 miles, to measure it thereby, which may be taken from 36 deg. to 38 deg. and the residue about 37 deg. as before, &c.

Or you may take the half of 430 miles, namely 215 miles, which is 3 deg. 35 min. which must be taken as before, about the middle of that part of the Meridian which is intercepted between the two Latitudes, and that doubled, is 430 miles to be set to the Eastward, as before.

And thus may this, or any other Reckoning be set down without knowledg of the Longitudes, but more aptly and exactly by some Longitudes known; for then shall you have in the two last Columns the substance and principal scope of your Reckoning, namely, the Latitudes and Longitudes of all places as you sail, which may more easily and



and exactly be express'd upon this *Chart*, than the Easterly or Westerly distances: Therefore how this also may be done we will shew: but first something touching the *Compass*, and the Variation thereof, which ought not to be neglected in a Reckoning.

## C H A P. X.

### *Of the Variation of the Compass, and how to rectify a Course by the Variation known.*

**A**Mongst all the Mysteries which God hath of late Years discovered to the World for the furtherance of NAVIGATION, there is none more necessary, nor yet more admirable than that Property of the *NEEDLE* touched with the Loadstone, whereby in the vast Ocean, where all the Landmarks fail, yea even in the darkest Nights and closest Weather, when neither Sun nor Stars are to be seen, the Mariner (as it were by a Messenger sent from Heaven) is taught which way to direct his Ship; yea, as it were accompanied with a Guide towards his desired Port.

For the Needle touched, besides other strange properties, hath this, to point out in all quarters of the World, the North and South parts of the Horizon, and so having a Card thereto fitted with Rhombs and Degrees, it sheweth all Points of the Compass, and Degrees of the Horizon.

Yet very seldom exactly of it self, without some farther Art and Industry of him that useth it; for though in some places it swerves not, yet in most parts of the World the North and South Points of the Needle have some Variation from the North and South parts of the Horizon, to the Eastwards or to the Westwards, which how to discover in kind and quantity, we have shewed heretofore.

It may be thought, (and some Men, otherwise learned, before this property was fully discovered, have said) that this should be some blemish and imperfection in a Stone so precious; but it is so far from being an imperfection, that it makes it so much the more precious: yet (as I have said) not without the industry of him that useth it. He that is negligent or unskilful to observe it, especially in long Voyages and various Courses, may be led into many dangers by it, because he frames not his Mind to the Rule, but the Rule to his Mind, imagining it to be what it is not: And hence I suppose sprang that Custom of placing the Needle, or Wiers, a Point, or half a Point, to the Eastwards of



the North Point of the Card, thinking by this means to shun the labour of observing the Variation; which indeed they might, if the Variation were the same in all places, and at all times; but because it is not, this doth often increase the Error.

But he that diligently observes the Variation, finds (as I say) no prejudice in it, only it requires daily, or once in two or three days, half an hours work; and this labour it doth abundantly recompence: for by this means he knows at the present how to direct his Course; and for the future, by those Notes which he keeps of the Variations and Latitudes by him observed, he knows (coming that way again) when he draws near to any of those places where such Observations were made, and so falls the more certainly with any place intended.

There is further discovered of late, a motion or alteration in the Variation of the Needle, and this is scarce yet certainly discovered. But comparing the Variations which were observed about fifty Years past, with the present Variations, it appears they are lesser Easterly, and more Westerly by 6 or 7 degrees, than they were at that time. For whereas the Variation hath formerly been observed near *London* to be  $11\frac{1}{4}$  deg. to the Eastwards, it doth now scarce exceed 4 degrees. And there is the like alteration (as I have heard by some Mariners) in other parts of the World; which we now leave to the farther discovery of Time and Industry, and come to shew how to rectify a Course by the Variation known.

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*The Point of the Compass upon which you sail, and the Variation of the Needle known, to find the Rhomb or Degree upon which the Ship hath made her way.*

**I**T is best that the Needle, or Wires, be placed directly under the Flower-de-luce, or North or South Points of the Card, and so in the Rules following we presuppose them to be. Now then it is to be understood, that the Needle having Variation (as for the most part it hath) the Ship doth not make her way upon the Rhomb, or Point of the Compass, which she seems to sail upon, but either more to the Right-hand or to the Left, according as the Variation is towards the Right-hand, or towards the Left, and that so much towards the one side, or towards the other, as that Variation is: We speak not here of Leeward-way, but of the Variation only. Therefore for the Solution of this Problem, you must know how much the Variation is, and



and which way ; and how this may be done, we have briefly shewed upon the 12th Case of Right-angled Spherical Triangles, and the 11th of Oblique ; which known, you may find the Angle of the Rhomb, or Line of your Ship's way with the Meridian, being the thing in this Problem required.

*A Table of the Angles of every Point and half Point of the Compass with the Meridian.*

	North.	South.	D. M.	North.	South.
			00 00		
$\frac{1}{2}$			05 37		
1	N. by E.	S. by W.	11 15	N. by W.	S. by E.
$1\frac{1}{2}$			16 52		
2	N. N. E.	S. S. W.	22 30	N. N. W.	S. S. E.
$2\frac{1}{2}$			28 07		
3	N. E. by N.	S. W. by S.	33 45	N. W. by N.	S. E. by S.
$3\frac{1}{2}$			39 22		
4	N. E.	S. W.	45 00	N. W.	S. E.
$4\frac{1}{2}$			50 37		
5	N. E. by E.	S. W. by W.	56 15	N. W. by W.	S. E. by E.
$5\frac{1}{2}$			61 52		
6	E. N. E.	W. S. W.	67 30	W. N. W.	E. S. E.
$6\frac{1}{2}$			73 07		
7	E. by N.	W. by S.	78 45	W. by N.	E. by S.
$7\frac{1}{2}$			84 22		
8	East.	West.	90 00	West.	East.
	Add East Variation, Subtract West.			Add West Variation, Subtract East.	

For the effecting whereof, we will set down two ways ; the one by the Pen alone, the other instrumentally. If you do it by the Pen alone, although it be not hard to find what Angle every Point, or half Point makes with the Meridian ; yet for your further ease herein, I have expressed the same in the Table before-going ; the quarters of Points I have omitted, because the Steerage upon a quarter of a Point is very uncertain,



uncertain, (the Points being undivided, as usually they are); for a Man is able by his Eye to guess very nearly which is the middle between two Points, but he cannot guess so nearly which is the fourth part. Yet if you desire any quarter, you may add to the next before-going almost 3 degrees, namely, 2 deg. 49 min.

Now then by the Magnetical Rhomb, or Point of the Compass, and Variation given, to find the Rhomb, you are to observe these two Rules following.

1. *If the Rhomb and Variation be both the same way from the Meridian (namely, both to the Right hand, or both to the Left) add them together, and that Sum is the true Rhomb from that part of the Meridian.*

*Yet if that Sum exceed 90 degrees, subtract it from 180 degrees, the Remainder is the Rhomb from the opposite part of the Meridian.*

2. *If the one be towards the Right-hand, the other towards the Left, subtract the Variation from the Rhomb, and the Remainder is the true Rhomb.*

*Yet if the Rhomb be the smaller number, subtract it from the Variation, and the Remainder is the true Rhomb the other way.*

These Rules we shall endeavour to illustrate by Examples following.

But first for distinction sake, we say the Rhombs or Degrees from the North towards the East, are towards the Right-hand, and so from the South towards the West, but from the North to the Westwards on the Left-hand, and so from the South Eastwards: For a Man's Face being towards the North, the East is on his Right-hand, and the West on his Left, &c.

In like sort for the Variation of the Compass; if it have Easterly Variation, that is, if the Needle and Flower-de-luce of the Card stand to the Eastwards of the North, we say that Variation is towards the Right-hand; for not only the North-Point, but all the other Points of the Compass direct a Course more towards the Right-hand than they would do if there were no Variation. And so if it have Westerly Variation, that is, if the Needle and Flower-de-luce stand to the Westwards of the true North-Point of the Horizon, we say that Variation is towards the Left-hand; forasmuch as not only the North-Point, but all the other Points of the Compass stand more towards the Left-hand than they would do if there were no Variation. This being premised, we come to give Examples of the two Rules before going.



1 *Example.* Let the Magnetical Rhomb or Point of the Compass be North-East, and the Variation 10 degrees to the Eastwards, I demand the true Rhomb ?

Here the Rhomb and Variation are both one way ;  
that is, both towards the Right-hand ; therefore

	deg.	min.
To the Magnetical Rhomb being North-Easterly	45	00
Add the Variation Easterly	10	00
The Sum is the true Rhomb North-Easterly	55	00

2 *Example.* Admit a Ship sails upon the North-Point of the Compass, and that the Variation be 10 deg. to the Eastwards ; how doth she make her way ?

The Magnetical Rhomb is North ; that is,	00	00
To which adding the Easterly Variation	10	00
The Sum is the Angle from the North part of the Meridian to the Eastwards	10	00

Which is almost N. by E. and so hath the Ship made her way.

3 *Example.* Let the Point of the Compass be East  $\frac{1}{2}$  Point Northerly ; that is, from the North to the Eastwards  $7\frac{1}{2}$  Points, which is 84 deg. 22 min, and the Variation, as before, 10 deg. to the Eastwards, I demand the true Rhomb ?

To the Magnetical Rhomb, being North East,	84	22
Add the Easterly Variation	10	00
The Sum is the Angle from the North	94	22
Which subtracted from	180	00
There rests the true Rhomb South-Easterly	85	38

4 *Example.* Let the Course by the Compass be West and by South ; that is, 7 Points from the South to the Westwards, or 78 deg. 45 min. and let the Variation be as before, 10 deg. to the Eastwards ; what is the true Rhomb ?

To the Magnetical Rhomb South-Westerly	78	45
Add the Easterly Variation	10	00
The Sum is the true Rhomb South-Westerly	88	45

You may conceive that the Rhomb and Variation are here both one way ; namely, both from the Meridian towards the Right-hand. For the Variation of the North-Point is from the North towards the East, and consequently of the South-Point from the South towards the West, both towards the Right-hand of the Meridian, as the Rhomb is.



5 *Example.* Let the Course by the Compass be West, that is, from the South to the Westwards 8 Points, or 90 Degrees, and let the Variation be, as before, 10 deg. to the Eastwards; I would know the true Course or Rhomb?

To the Magnetical Rhomb South-West ————— 90 00

Add the Variation Easterly ————— 10 00

The Sum is the Angle with the }  
South part of the Meridian } ————— 100 00

Which subtracted from ————— 180 00

There rests the true Rhomb North-West ————— 80 00

Let the Course of the Compass be West; that is, from the North to the Westwards 8 Points, or 90 Degrees, and let the Variation be 10 deg. to the Westwards; I demand the true Rhomb?

To the Magnetical Rhomb North-West ————— 90 00

Add the Variation Westerly ————— 10 00

The Sum is ————— 100 00

Which subtracted from ————— 180 00

There remains the true Rhomb South-West ————— 80 00

*Object.* The Magnetical Rhomb being here West 90 deg. why should it not as well be counted from the South, as from the North?

*Ans.* It may be counted from either; for as it is counted here from the North to the Westwards, it falls under the first Rule, because the Variation is the same way; But if it be reckoned from the South to the Westwards, it falls under the second Rule, whereof we now come to give some Examples, supposing these already given sufficient to illustrate the first Rule.

7 *Example.* Let the Point of the Compass be N. N. W. and the Variation 10 deg. Easterly; I demand the true Rhomb?

From the Magnetical Rhomb North-West ————— 22 30

Subtract the Easterly Variation ————— 10 00

The Remainder is the true Rhomb North-West ————— 12 30

8 *Example.* Let the Point of the Compass be North, and the Variation Easterly 10 deg. what is the true Rhomb?

From the Easterly Variation ————— 10 00

Subtract the Magnetical Rhomb N. W. ————— 00 00

The Remainder is the true Rhomb }  
the other way, namely, N. E. } ————— 10 00

*Object.*



**Object.** The Magnetical Rhomb may as well be named North-Easterly 0 deg. 0 min.

**Ans.** It may; but then it is subject to the first Rule, as in the second Example.

**9 Example.** Let the Course by the Compass be West, that is, from the North to the Westwards, 8 Points, or 90 Degrees, and let the Variation be, as before, 10 deg. to the Eastwards; what is the true Rhomb?

From the Magnetical Rhomb N. W. ————— 90 00

Subtract the Easterly Variation ————— 10 00

There rests the true Rhomb N. W. ————— 80 00

Here the Magnetical Rhomb might as well be South-Westerly 90 deg. and so it had fallen under the first Rule, as in the fifth Example.

**10 Example.** Let the Course by the Compass be West, that is, from the South to the Westwards 8 Points, or 90 Degrees, and let the Variation be 10 deg. to the Westwards, I demand the true Rhomb?

From the Magnetical Rhomb S. W. ————— 90 00

Subtract the Westerly Variation ————— 10 00

The Remainder is the true Rhomb S. W. ————— 80 00

If the Rhomb here had been reckoned from the North, as in the sixth Example, it had fallen under the first Rule.

And this may suffice for the illustration of the two former Rules in the solution of this Problem.

The same may also more easily be resolved, by such an Instrument as is here described, consisting of two Circles; the one being the nethermost, divided into 4 Quadrants; and every of those into 90 deg. numbred from the North and South Points, towards the East and West.

The other, being the uppermost, and moveable about the Center, divided as the Card of the Compass into XXXII Points, and those again subdivided into halves and quarters.

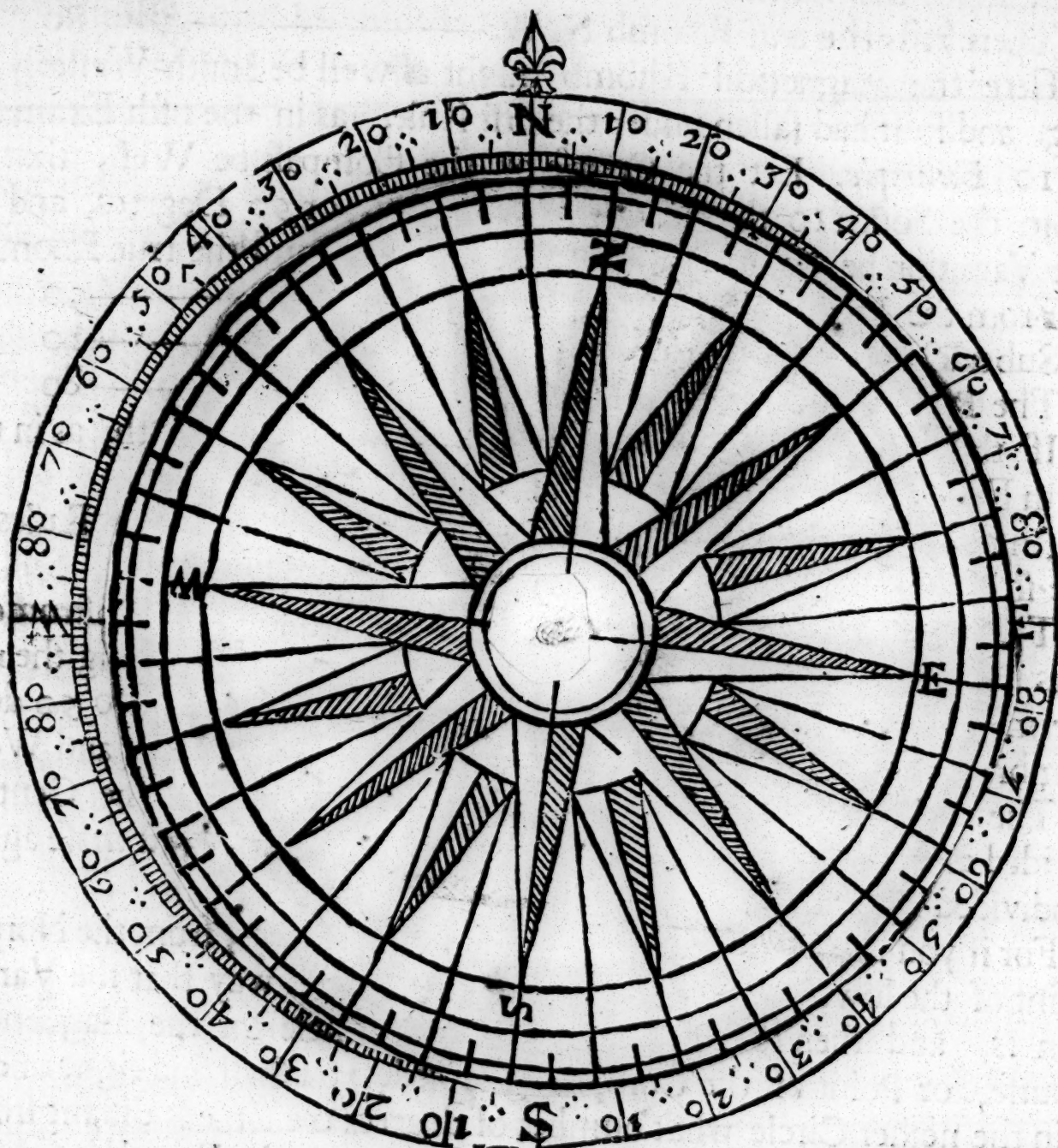
For if you turn the North-Point of the upper Circle, from the North-Point of the lower so many degrees, and the same way that the Variation is, and then look in the same upper Circle for the Magnetical Course, or Point of the Compass proposed, you shall find right under it in the nether Circle what number of degrees the same is distant from the N. or S. Points of the true Meridian towards the E. or W. which is the true Rhomb here required.

As, suppose the Variation to be 10 deg. Easterly, and the Course by the Compass East, half a Point Northerly, and there be required the true Rhomb.



I turn the North-Point of the upper Circle from the North-Point of the lower 10 deg. to the Eastwards, and then I look in the upper Circle, for East half a Point Northerly, and right under it in the nether Circle I find 85 deg. and about one half, numbred from the South-part of the Meridian towards the East; therefore I conclude, that the true Rhomb required is from the South towards the East,  $85\frac{1}{2}$  deg. and something more.

By this you may readily find the true Rhomb for any Course and Variation given.



By this Instrument also (if you use the Pen only, as before we have shewed) you shall readily see when to add, and when to subtract.



## C H A P. XI.

*To keep a Reckoning of your Longitude, and so to set down a Reckoning by Longitude and Latitude only.*

**I**N this Example before given of a Journal, we have in the twelfth and last Colomn, expressed in such places as it seemed most requisite, the Longitudes: we come now to shew how the same may be known; and first,

*By the Rhomb and Latitude given, to find the difference of Longitude.*

As the Radius is in proportion to the Tangent of the Rhomb;

So is the difference of Latitude in Meridional Parts,

To the difference of Longitudes in Minutes.

As, let the Rhomb be North-Easterly 48 deg. and suppose a Ship to run upon this Rhomb, from the Latitude of 32 deg. 25 min. into the Latitude of 34 deg. 24 min. there is required the difference of Longitude.

Here,

The Meridional Parts answering to 34 deg. 24 min. .2200

The Meridional Parts for 32 25 .2058

The difference of Latitude in such parts is ————— 142

Say then, As Radius is in proportion,

To the Tangent of the Rhomb, *t.* 48 deg. 00 min. ——— 10.0456

So the difference of Latitude in Merid. Parts, ——— 142 2.1523

To the difference of Longitude in Minutes ——— 158 2.1979

These Minutes converted into Degrees, are 2 deg. 38 min. which is the difference of Longitude required, as the same is expressed in the Journal against the 21 of *February*.

And thus sailing upon one and the same Rhomb, you may find the difference of Longitude; and so often as you alter your Rhomb, so often working by the same Rule, you shall have all the differences from place to place, which added together, make the whole difference of Longitude.

But you may also find the difference of Longitude near enough at one Operation for many Rhombs and Distances, provided that those Rhombs differ not much one from another. As in the former Journal from the 27 of *February*, till the second of *March*, I sail by several Rhombs and Distances from the Latitude of 43 deg. 55 min. into the Latitude of 48 deg. If you would find the difference of Longitude hereto answerable at one Operation, it may be done by this Rule.

As



As the difference of Longitude in Miles,  
Is to the departure from the Meridian in Miles;  
So is the difference of Latitude in Meridional Parts,  
To the difference of Longitudes in Minutes.

As in that Example, the difference of Latitude for all those Courses, as in the North Column appears, is 2444.

The Departure from the Meridian, as there in the East Column appears, is 6301.

The Merid. parts for the Latitude of 43 deg. 55 min. are 2939

The Merid. parts for the Latitude of 58 deg. 00. min. are 3292

The difference of Latitude in Meridional Parts, is ———— 353

Say then, As the difference of Latitude — 2444 *Co. ar.* 6.6119

To the departure from the Meridian — 6301 3.7994

So the difference of Latitude in Merid. Parts 353 2.5478

To the difference of Longitude in minutes 910 2.9591

Which reduced into degrees, is 15 deg. 10 min. And added to the former Latitude 21 deg. 28 min. gives the present Longitude 36 deg. 38 min. for the 2d of *March*.

The like may be done for the account from the 2d of *March* to the 5th of the same, &c.

But if your Courses and Distances run, be all near to one and the same Parallel or Latitude (as in this Journal they are from the 5th of *March* to the 8th, and from the 8th to the 10th,) then it is sufficient to find what Longitude in that Parallel is answerable to the Miles of Easting or Westing, or departure from the Meridian, by this Rule.

As the Sine Complement of the Latitude of that Parallel,

Is in proportion to *Radius*;

So is the number of Miles in that Parallel,

To the difference of Longitude in Minutes.

As from the 5th of *March* to the 8th, the Latitude was near 50 deg. the Easterly distance 186  $\frac{8}{10}$  Miles: therefore for the difference of Longitude, say;

As Sine Complement the Latitude, *s. c.* 50. deg. 0 min. .1919

To *Radius*;

So is the departure from the Meridian ———— 186 8 3.2714

To the difference of Longitude ———— 290 6 3.4633

Thus it appears, the difference of Longitude is almost 291 min. which is 4 deg. 51 min. and this added to the Longitude upon the 5th of *March*, namely, to 46 deg. 52 min. the Sum is 51 deg. 43 min. the



the Longitude for the 8th of March: the like might be done for the 10th of March.

And though this last Rule be then fittest to be used, when your Course is near East and West, or your difference of Latitude little, yet it may also be used at other times instead of the two former, without any great Error, if you take the middle degree of Latitude, or somewhat more, as in the former Example.

The Latitude upon the 27th of February is ————— 43 55

The Latitude upon the 2d of March is ————— 48 00

The middle Latitude, or somewhat more, is ————— 46 10

Say then ;

As Sine Complement the Latitude *s. c.* 46 deg. 10 min. .1595

To Radius ;

So the Easting or departure from the Merid. 630 1' 3.7994

To the difference of Longitude ————— 909 7' 3.9589

Which is almost 910 min. or 15 deg. 10 min. as before.

And thus you may in the twelfth and last Column of your Journal set down your Longitude, so often as you think it requisite ; and so in to two last Columns you shall have the substance and principal scope of your Reckoning, namely, your Latitudes and Longitudes, which whensoever you desire to set down in *Mercator's Chart*, or in the *Polar Chart*, or in any other, graduated with Degrees of Longitude and Latitude, you may readily do it.

As if you would set down the sum of the foresaid Journal from the 19 of February to the 10 of March, I find against the 10 of March the Latitude to be 49 deg. 54 min. and the difference of Longitude 54 deg. 53 min. Therefore in the Latitude of 49 deg. 54 min. I draw an occult Parallel, and reckoning from *Summer Islands* towards the East 54 deg. 53 min. I draw by that Longitude an occult Meridian ; the Intersection of this Meridian with the aforesaid Parallel, is the Traverse-Point, or the Point representing the place of the Ship : and the like is to be understood of any other.

This form of keeping and expressing a Reckoning, (is as I conceive) most apt and agreeable (of all others that I have seen or thought upon) to all sorts of *Charts* or *Maps*, and to the *Globe* it self, and to all the kinds or ways of Sailing, that are or may be used. We will here add some other Propositions which may sometimes be of good and necessary use in it.



*The Rhomb and Difference of Latitude given, to find by the Table the Distance in the Rhomb, and the Departure from the Meridian whereto answerable, &c.*

**H**OW to find the Northing or Southing, that is, the Distance in Latitude; as also the Easting or Westing, that is, the distance in Longitude, or departure, from the Meridian of any Rhomb, for any distance run upon it, we have before shewed: the like Operation is in these Proportions following; namely,

2. *The Rhomb and Distance in Latitude given: to find the Distance in the Rhomb, and the Easting or Westing.*

3. *The Distance and Difference in Latitude given: to find the Departure from the Meridian and the Rhomb.*

4. *The Difference in Latitude, and Departure from the Meridian given; to find the Course and Distance.*

5. *The Course and Departure from the Meridian given; to find the difference of Latitude and Distance.*

6. *The Distance and Departure from the Meridian given; to find the Course and difference of Latitude.*

So that with the first before-handled, here are six Propositions, and in every one of them two things required; and so they become twelve. We will not stand to give Examples of them all, but only of those which are most useful, the rest may be by them conceived.

And first, to find the Easting or Westing of any Rhomb for any difference of Latitude.

Admit a ship run North-easterly 60 deg. (that is, N. E. by E. and almost half a Point Easterly) till she have altered the Latitude 42 min. how much is she departed from the Meridian?

I run down the Column under 60 degrees till I find 42 Miles, or 420 tenths, and against it in the adjacent Column I find 728 tenths, that is, almost 73 miles; which is the Departure from the Meridian to the Eastwards.

If you would also have the Distance upon the Rhomb, it is right against these numbers in the Column of Distances, being in this Example 84 miles.

2. *Example,* But admit she run North-easterly 60 deg. till she alter her Latitude 1 deg. 32 min. what is the Easterly distance?

This 1 deg. 32 min. is 92 miles, or 920 tenths, for which if I look in the Column under 60 deg. I find no number so great, but the greatest number there is 500, which subtracted from 920, there remains



420; therefore in that Column under 60 deg. I look for these two numbers, namely 500 and 420, and against the first in the adjacent Column I find 866, and against the second 728, which I set against them as above appeareth, and so adding them, I find for this difference of Latitude, the departure from the Meridian to be 159<sup>4</sup> miles.

100	500	866
84	420	728
<hr/>		
184	920	1594

If further you desire the distance run upon this Rhomb, you have it in the Column of Distances, right against the same numbers, as in the Example above appeareth, where being added, it amounts to 184 Miles.

*The Distance and Difference in Latitude given; to find the Rhomb and Departure from the Meridian.*

**A**dmit a Ship run upon some Rhomb between the North and the East 84 Miles, and then have altered her Latitude 42 min. the Question is, Upon what Rhomb hath she run, and how many Miles is she to the Eastwards in Longitude?

I run cross the Table towards the right hand, looking in every first Column of Distances for 84, till I find against it in one of the adjacent Columns 420; at the top of which Column over 420, there is 60 deg. shewing the Rhomb to be North-Easterly 60 deg. also against 420 in the adjacent Column, I find 728, which sheweth the Distance to the Eastwards to be almost 73 Miles.

2. *Example.* But if the Distance run be 184 Miles, and the difference of Latitude 1 deg. 32 min. and there be required the Rhomb and Distance to the Eastwards.

Because the Column of Distance extends but to 100 Miles, and the distance here given is 184 Miles, you may take the half thereof, which is 92 Miles, and likewise the half of 1 deg. 32 min. which is 46 Miles, or 460 tenths; and then look, as before, where you find 460 against 92, for there in the top of the Column you shall find the Rhomb, which in this Example is 60 deg. shewing that the Rhomb is from the North Easterly 60 deg. and in the adjacent Column against 92 and 460 you shall find 797, which doubled (because it is for the half) is 1594, shewing that the departure from the Meridian to the Eastwards is 159<sup>4</sup> Miles. These and the rest may also be performed by the *Doctrine of Plain Triangles*, as we have formerly shewed.



## CHAP. XII.

*Certain Problems touching Currents.*

**A**Lthough the time be already expired which I assigned for this Work, and mine own more urgent Occasions call me away, yet seeing it is necessary in *Navigation* to take notice of Currents, and to make a competent allowance for them; I will briefly set down certain *Problems*, such as I have sometimes thought upon, whereby a man may the better conceive and judg of that allowance, the rather for that I know not any that have handled it.

First then, it is to be conceived, that a Ship or other Vessel sailing or rowing where there is a Current, hath a compound Motion arising of two different Principles; namely, of the Current and Ship's way; so that here are three Motions to be considered, namely, two simple, and the third compounded of them. The simple Motion is that of the Current, whereby it moveth, and is apt to move other things that are in it in the same way. The second, of the Ship or Boat, as it moveth by Wind or Oars, or is apt to be moved, if there were no Current. The third, compound of them, is the Line of the Ship's true Motion. The first, we call the Way or Motion of the Current; the second, the Way, or simple Motion of the Ship; the third, her compound or true Way. The two simple Motions being either of them according to right Lines, and uniform, as in the *Problems* following we suppose them to be. The third also, which is composed of them, is a right Line; for whether the Ship sail directly opposite against the Current, or directly with it the same way, or whether the one cross the other at Right-Angles or at Oblique; yet still either Motion being direct and uniform, they both together beget a right-lin'd uniform Motion, because the one retaineth to the other one, and the same proportion in every Point: And according to these grounds we proceed in the *Problems* following to determine the Proportions of every of these Motions, and the Angles which they make one with another.

1. *Admitta Current run East 3 Miles an hour, and that a Ship under Sail run West directly against it 6 Miles an hour in her simple Motion, What is her true or compound Motions?*

From the Ship's simple Motion \_\_\_\_\_ 6 Miles,  
Subtract the Current \_\_\_\_\_ 3 Miles;  
The Remainder is the Ship's true Motion \_\_\_\_\_ 3 Miles.

So the Ship's true way is to the Westwards 3 miles an hour.

2. *Ad-*



Admit a Current run West 6 Miles an hour, and that a Ship under Sail run directly against it 5 Miles an hour by the Log : What is the Ship's compound Motion, and which way?

From the Current, being the greater ————— 6 Miles,  
Subtract the Ship's simple motion ————— 5 Miles;  
There remains the Ship's true Motion ————— 1 Mile.

Which 1 Mile shews, that the Ship by her compound Motion falls astern, that is, moves to the Westwards 1 mile an hour.

In the experimental Practice of the two former Problems it may seem, that a Ship or Boat so ordered, hath also a Motion to the right-hand or to the left ; but this comes to pass, because it is hard, and in a manner impossible to stem a Tide or Stream so exactly, but that the Ship will swerve (or yaw, as they say) either to one side or to the other.

3. Admit a Current run East 3 Miles an hour, and that the Ship also run East 3 Miles an hour, by the Log : What is the Ship's true Motion?

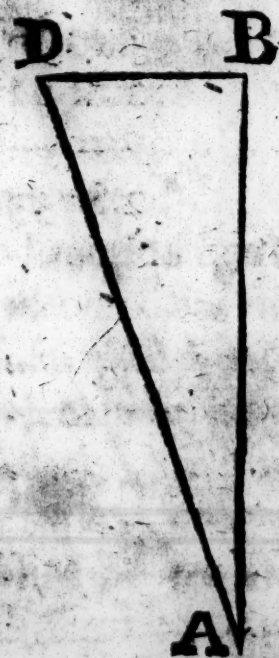
To the Ship's simple Motion ————— 3 Miles,  
Add the Current ————— 3 Miles;  
The Sum is the Ship's true Motion ————— 6 Miles.

So the Ship's compound or true way, is East 6 Miles an hour.

4. Admit a Current run East 2 Miles an hour, and the Ship South 6 Miles an hour : What is the Ship's true Motion, and which way?

In handling of any Art to avoid circumlocution, there are used Terms or words of Art serving to express briefly the things handled. And forasmuch as this Subject hath not been formerly handled, nor the Principles or Grounds thereof laid (so far as I know;) we will add a few such terms as may seem most necessary, expressing here what we mean by them.

Let the Line A B run from A to the Southwards, and B D from B to the Eastwards, and let A B be in proportion to B D, as 6 to 2, or 3 to 1.



Then doth A B represent the line of the Ship's simple Motion, B D the Motion of the Current, and A D the compound Motion of the Ship.

And D A B is the Angle contained between the line of the Ship's simple Motion, and the line of her compound or true Motion, which for brevity sake we will henceforth call the *Angle of Deflection*. Also A D B is the Angle contained between the line of the Ship's Compound Motion, and the set or drift of Current, which we call the *Angle of Reflection*.

Lastly,



Lastly, ABD is the Angle contained between the line of the Ship's simple Motion, and the set of the Current, which we will call the *Angle of Incidence*.

Then for the Rhomb, the Proportion is thus.

As the simple Motion	AB 6 miles	co. ar.	9.2219
Is to the Current	BD 2 miles		0.3011
So is Radius,			—

To the Tangent of Deflection <i>t.</i> DAB	18 deg. 26 min.		9.5230
--	-----------------	--	--------

So the Rhomb upon which the Ship makes her way good, is South 11 deg. 26 min. Easterly, that is, S. S. E. 4 deg. 4 min. Southerly.

2. For the Ship's true Way, or compound Motion :

As the Sine of the Deflection <i>f.</i> DAB	18 deg. 26 min.		0.5000
To the Current	DB 2 miles		0.3011
So Radius,			—

To the true Motion	AD $6\frac{1}{3}$		0.8011
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So the Ship's Compound Motion is  $6\frac{1}{3}$  miles hourly, that is  $6\frac{1}{3}$  miles almost.

5. A Ship sails West 5 days together, by the Log. 725 Miles: but there is a Current all this while setting to the Southwards  $1\frac{1}{2}$  Miles an hour: I demand how she hath sailed, and how far?

The Current setting  $1\frac{1}{2}$  mile an hour, sets in 5 days 180 Miles:

Therefore,

As the simple Motion	AB 725 miles		7.1397
Is to the Current	DB 180 miles		2.2553
So is Radius			—

To the Tangent of Deflection <i>t.</i> DAB	13 deg. 57 min.		9.3950
--	-----------------	--	--------

For the Distance.

As Sine-compl. the Deflections <i>f.</i> DAB	13 deg. 57 min.		0.0130
Is to the simple Motion	AB 725 miles		2.8603
So is Radius			—

To the compound Motion	AD 747 miles		2.8733
------------------------	--------------	--	--------

So the Ship's true way is West-southerly 13 deg. 57 min. or South-westerly 76 deg. 3 min. 747 miles.

6. A Ship sails West 5 days together, by the Log. 725 miles, in a Current setting to the Southwards, and then finds that she hath altered her Latitude 3 degrees; I demand the Motion of the Current, the true Rhomb, and true way of the Ship?

This Question differeth little from the former: for seeing the Difference of Latitude is 3 deg. the Motion of the Current is 180 miles: so there is given the Ship's simple Motion, and the Motion of the Current, as before, &c.



7. A Ship in 6 hours sails from a certain Cape or Head-land South, 30 miles by the Log. in a Current setting Easterly; and then observing the same Cape, he finds that it bears N N W. I demand how fast that Current sets, and how far she hath sailed?

As let a Ship sail from A towards B South 30 miles; but by means of the Current, she is driven more Easterly, namely to D; from whence setting the Cape A, it is found to bear N N W. And seeing the Current sets from B towards D Easterly; therefore the Angle of Reflection BDA is 6 Points, that is, 67 deg. 30 min. Here then is demanded the distance A D, and the drift of the Current in that time B D.

As the Sine of the Angle of Deflection $\angle$ BDA 67 d. 30 min.	.0344
To the simple Motion of the Ship A B 30 miles	1.4771
So the Sine of the Angle of Deflection $\angle$ DAB 22 d. 30 min	9.5736
To the Motion of the Current BD $12 \frac{1}{2}$	1.0851

And further,

As the Sine of the Angle of Reflections BDA 67 d. 30 m.	.0344
To the distance run by the Log A B 30 miles,	1.4771
So is Radius	—

To the compound Motion of the Ship A D $32 \frac{1}{2}$	1.5115
---	--------

And thus we find that Current to set  $12 \frac{1}{2}$ ; that is near  $12 \frac{1}{2}$  miles in 6 hours, and the distance run to be  $32 \frac{1}{2}$  miles almost.

That the thing may be better conceived, we will use two or three Examples more familiar and obvious to every man's experience; yet grounded upon the same Principles and Reasons.

8. Admit that Tulis-stairs bear from Billingsgate-stairs South-west southerly, namely, South-westerly 40 degrees, and be distant 80 Poles; and suppose the Tide of Ebb to run there Eastward  $2 \frac{1}{2}$  miles an hour, and that a pair of Oars rowing  $4 \frac{1}{2}$  miles an hour, would go straight over from the first to the second: How shall they row over, namely, upon what Degree or Point of the Compass, and how far shall they row to get thither, and in what time?



Let A represent Billingsgate-stairs, D Tulis stairs, AE the simple Motion of the Boat, ED the motion of the Current, then is A the Angle



Lastly, ABD is the Angle contained between the line of the Ship's simple Motion, and the set of the Current, which we will call the *Angle of Incidence*.

Then for the Rhomb, the Proportion is thus.

As the simple Motion	AB 6 miles	co. ar.	9.2219
Is to the Current	BD 2 miles		0.3011
So is Radius,			—

To the Tangent of Deflection t. DAB	18 deg. 26 min.		9.5230
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So the Rhomb upon which the Ship makes her way good, is South 11 deg. 26 min. Easterly, that is, S. S. E. 4 deg. 4 min. Southerly.

2. For the Ship's true Way, or compound Motion :

As the Sine of the Deflection s. DAB	18 deg. 26 min.		0.5000
To the Current	DB 2 miles		0.3011
So Radius,			—

To the true Motion	AD $6\frac{1}{2}$		0.8011
--------------------	-------------------	--	--------

So the Ship's Compound Motion is  $6\frac{1}{2}$  miles hourly, that is  $6\frac{1}{2}$  miles almost.

5. A Ship sails West 5 days together, by the Log. 725 Miles: but there is a Current all this while setting to the Southwards  $1\frac{1}{2}$  Miles an hour: I demand how she hath sailed, and how far?

The Current setting  $1\frac{1}{2}$  mile an hour, sets in 5 days 180 Miles;

Therefore,

As the simple Motion	AB 725 miles		7.1397
Is to the Current	DB 180 miles		2.2553
So is Radius			—

To the Tangent of Deflection t. DAB	13 deg. 57 min.		9.3950
-------------------------------------	-----------------	--	--------

For the Distance.

As Sine-compl. the Deflections s. DAB	13 deg. 57 min.		0.0130
Is to the simple Motion	AB 725 miles		2.8603
So is Radius			—

To the compound Motion	AD 747 miles		2.8733
------------------------	--------------	--	--------

So the Ship's true way is West-southerly 13 deg. 57 min. or South-westerly 76 deg. 3 min. 747 miles.

6. A Ship sails West 5 days together, by the Log. 725 miles, in a Current setting to the Southwards, and then finds that she hath altered her Latitude 3 degrees; I demand the Motion of the Current, the true Rhomb, and true way of the Ship?

This Question differeth little from the former: for seeing the Difference of Latitude is 3 deg. the Motion of the Current is 180 miles: so there is given the Ship's simple Motion, and the Motion of the Current, as before, &c.



7. A Ship in 6 hours sails from a certain Cape or Head-land South, 30 miles by the Log. in a Current setting Easterly; and then observing the same Cape, he finds that it bears N N W. I demand how fast that Current sets, and how far she hath sailed?

As let a Ship sail from A towards B South 30 miles; but by means of the Current, she is driven more Easterly, namely to D; from whence setting the Cape A, it is found to bear N N W. And seeing the Current sets from B towards D Easterly; therefore the Angle of Reflection BDA is 6 Points, that is, 67 deg. 30 min. Here then is demanded the distance A D, and the drift of the Current in that time B D.

As the Sine of the Angle of Deflection $\angle$ BDA 67 d. 30 min.	.0344
To the simple Motion of the Ship A B 30 miles	1.4771
So the Sine of the Angle of Deflection $\angle$ DAB 22 d. 30 min	9.5736
To the Motion of the Current B D 12 $\frac{1}{2}$	1.0851

And further,

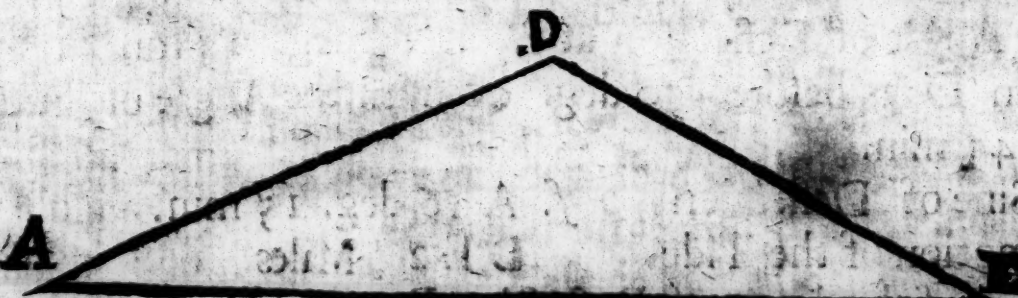
As the Sine of the Angle of Reflections BDA 67 d. 30 m.	.0344
To the distance run by the Log A B 30 miles,	1.4771
So is Radius	—

To the compound Motion of the Ship A D 32 $\frac{4}{7}$	1.5115
---	--------

And thus we find that Current to set 12  $\frac{1}{2}$ ; that is near 12  $\frac{1}{2}$  miles in 6 hours, and the distance run to be 32  $\frac{1}{2}$  miles almost.

That the thing may be better conceived, we will use two or three Examples more familiar and obvious to every man's experience; yet grounded upon the same Principles and Reasons.

8. Admit that Tulis-stairs bear from Billingsgate-stairs South-west southerly, namely, South-westerly 40 degrees, and be distant 80 Poles; and suppose the Tide of Ebb to run there Eastward 2  $\frac{1}{2}$  miles an hour, and that a pair of Oars rowing 4  $\frac{1}{2}$  miles an hour, would go straight over from the first to the second: How shall they row over, namely, upon what Degree or Point of the Compass, and how far shall they row to get thither, and in what time?



Let A represent Billingsgate-stairs, D Tulis stairs, AE the simple Motion of the Boat, ED the motion of the Current, then is A the Angle



Angle of Deflection, E the Angle of Incidence, D the Angle of Reflection, 130 deg. or 50 deg.

As the simple Motion of the Boat AE  $4\frac{1}{2}$  Miles ——— 9.34679

Is to the Motion of the Tide DE  $4\frac{1}{2}$  miles ——— 0.39794

So the Sine of Reflection Ds 50 deg. ——— 9.88428

To the Sine of Deflection As 23 deg. 3 min. ——— 9.62895

Thus then the Position from A to D, being South-Westerly 40 deg. and the Angle of Deflection A 23 deg. 3 min. the position from A towards E, is South-westerly 63 deg. 3 min. that is, W. S. W. Southerly. And so must those Oars row to go streight over.

*Secondly, for the Distance A E.*

From the Angle of Reflection ——— D 50 deg. 00 min.

Subtract the Angle of Deflection ——— A 23 deg. 03 min.

And there rests the Angle of Incidence E 26 deg. 57 min.

As the Sine of Incidence f. E 26 deg. 57 min. 0.34370

To the true Distance A D 80 Poles. 1.90309

So the Sine of Reflection f. D 50 deg. 00 min. 9.88425

To the simple motion A E  $135\frac{1}{2}$  Poles. 2.13104

*Lastly, for the time.*

Seeing 320 Poles make a Mile, and they row  $4\frac{1}{2}$  Miles an hour, it is 1440 Poles in an hour; so the proportion is,

As the simple hourly motion 1440 6.8416

To the simple motion before found  $135\frac{1}{2}$  2.1310

So is an hour in minutes, namely, 60 min. 1.7781

To the time required in minutes  $5\frac{6}{10}$  0.7507

And so long will they be rowing over.

9. But suppose they row harder, to go a shorter cut; namely, to go South-West by West: How fast must they go to row streight over, and how far, and in what time?

Then seeing the Proposition from A to D is South-westerly 40 deg. and South-West by West is South-westerly 56 deg. 15 min. therefore the Angle of Deflection at A, is 16 deg. 15 min. the Angle of Reflection D as before, 50 deg. 00 min. the Angle of Incidence E is 33 deg. 45 min.

As the Sine of Deflection f. A 16 deg. 15 min. .55311

To the motion of the Tide DE  $2\frac{1}{2}$  Miles 0.39794

So the Sine of the Angle of Reflection D 50 deg. 0 min. 9.88425

To the simple hourly motion of the Boat A E  $6\frac{8}{10}$  0.83530

And such is the hourly motion of the Boat, namely,  $6\frac{8}{10}$  Miles in an hour.

*Secondly,*



*Secondly, for the simpl<sup>r</sup> motion.*

As the Sine of Incidence	$\angle E$ 33 deg. 45 min.	0.25526
Is to the true distance	A D 80 Poles	1.90309
So the Sine of Reflection	D 50 deg. 00 min.	9.88425
To the simple motion	A E 110 <sup>3</sup> Poles	2.04260

Thus it appears they must row 110<sup>3</sup> Poles to get over.

*Lastly, for the time.*

The hourly motion before found	$6\frac{8}{10}\frac{4}{10}\frac{4}{10}$ reduced	
into Poles, is		2.190 <sup>1</sup>
As the simple hourly motion	2190	6.65956
Is in proportion to an hour, or	60 min.	1.77813
So is the simple motion before found	110 <sup>3</sup>	2.04260
To the time required	$3\frac{0}{10}\frac{2}{10}\frac{2}{10}$ min.	0.48031

And so long they will be rowing over.

10. But admit a Sculler rowing 3 miles an hour, would cross straight over at the same time, upon what Point must he row, and how far to get thither, and in what time will he do it?

*First, for the Angle of Position.*

As the hourly motion of the Boat	A E 3 miles	9.52288
To the Sine of Reflection	D $\angle$ 50 deg.	9.88425
So is the hourly motion of the Stream	D E 2 <sup>1</sup> / <sub>2</sub> min.	0.39794
To the Sine of Deflection	A $\angle$ 39 deg. 40 min.	9.80507

Now seeing the position from Billingsgate to Tulis-stairs, namely, from A to D, is by supposition to the Westwards of the South 40 deg. and the Angle of Deflection A is here found to be 39 deg. 40 min. therefore the position from A to E is from the South to the Westwards 79 deg. 40 min. which is W. and by S. and almost 1 deg. Westerly, and so must that Sculler row to go streight over.

*Secondly, for the Distance A E.*

From the Angle of Reflection	D	50	00
Subtracting the Angle of Deflection	A	39	40
There rests the Angle of Incidence	E	10	20
As the Sine of Incidence	$\angle E$ 10 deg. 20 min.	.74624	
To the true distance	A D 80 Poles	1.90309	
So is the Sine of Reflection	$\angle D$ 50 deg. 00 min.	9.88425	
To the simple motion	A E 341 <sup>6</sup> Poles	2.53358	

And thus it appears, that though the distance of the two places be but 80 Poles, yet if according to the Question, he rows but after



3 miles an hour, and the Stream set after  $2\frac{1}{2}$  miles an hour, then he must row  $341\frac{6}{10}$  Poles, to go streight over.

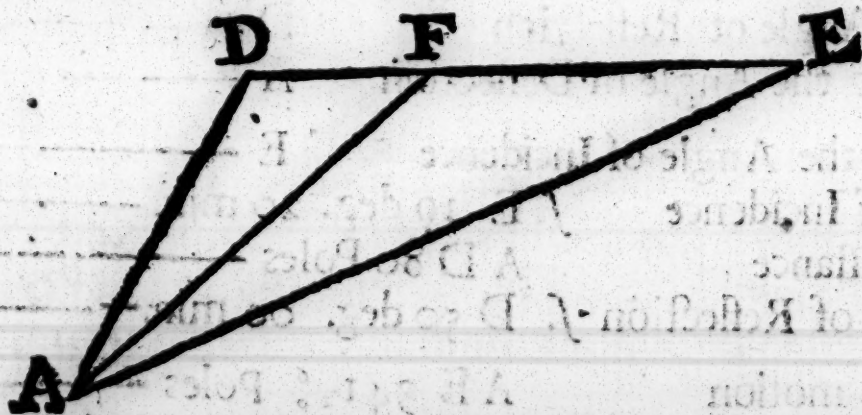
*Lastly, for the Time.*

Three miles is 960 Poles; say then,		
As the simple hourly motion	960	7.01773
To the simple motion before found	$341\frac{6}{10}$	2.53358
So is an hour in minutes, namely	60 min.	1.77815
To the time required in minutes	$21\frac{3}{10}$	1.32946

And thus it appears, that the time requisite to row over, rowing 3 miles an hour, is  $21\frac{3}{10}$  minutes; whereas we found before, that rowing there  $4\frac{1}{2}$  miles an hour, they might row over in  $5\frac{6}{10}$  minutes, which is little more than a fourth part of the time.

There might be other, and that great variety of Questions of this nature proposed and resolved, many of good use in practice, which the Watermen, by daily experience without other Rules, are able to guess at something nearly, sufficing for their occasions: My intent in these especially, is to explicate the Compound Motion of a Ship, or other Vessel, sailing or rowing where there is a Current; which by such familiar Examples may seem more evident. I cannot insist upon them by reason of my other occasions, nor spend that time in these here handled, which else I should have done; whence if any defect or mistake should arise, if the Reader be pleased to give me friendly notice of it, I shall as thankfully accept it, and reform it. We purpose next a Question at Sea, which let be this.

11. *There is a Current at Sea setting East 12 miles in 24 hours a Ship sails in the time from a certain Port West-South-West six days, and then returning thence, and sailing North-East and by North 3 days, falls with the Port from whence she first departed, I demand what her Dead-Reckoning was outwards, and what back again, and how far these two Ports were asunder, and upon what Point of the Compass?*



As, let the Current set from E towards D, and let the first Port be A, the second F, and let the Course outwards bound be repre-



represented by A E, and the Course homeward by D A, &c.

And forasmuch as D E is an East and West Line, and A E West South-West, therefore the Angle at E is 22 deg. 30 min. and by the like reason, the Angle at D is 123 deg. 40 min. or 56 deg. 15 min. and the Angle at A 33 deg. 45 min. and E D being the setting of the Current for 9 days, is 108 miles.

*First then, for the dead Reckoning outwards, namely, A E.*

As the Sine of the Angle at A $\angle$ 33 deg. 45 min.	—	—	—	—	25526
To the Line D E 108 miles	—	—	—	—	2.03342
So is the Sine of the Angle D $\angle$ 56 deg. 15 min.	—	—	—	—	9.91985
To the Line A E	—	—	—	—	74 $\frac{1}{4}$ miles 2.20853

Thus A E his Dead Reckoning outwards is 161 $\frac{1}{4}$ .

*Secondly, for A D.*

As the Sine of the Angle D A E $\angle$ 33 deg. 45 min.	—	—	—	—	25526
Is to the Line D E	—	—	—	—	108 miles 2.03342
So is the Sine of the Angle D E A $\angle$ 22 deg. 30 min.	—	—	—	—	9.58284
To the Line A D	—	—	—	—	74 $\frac{1}{4}$ miles 1.87152

Which 74 $\frac{1}{4}$  miles is the Dead-Reckoning homewards.

*Thirdly, for the Angle D A F or D F A.*

The side A D is found — 74 $\frac{1}{4}$  miles.

The side D F for three days is 36 miles.

The Sum of both is — 110 $\frac{1}{4}$ .

Their difference is — 38 $\frac{1}{4}$ .

The Sum of the Angles D A F and D F A 56 deg. 15 min.

The half Sum is — 28 deg. 7 $\frac{1}{2}$  min.

*The Proportion.*

As the Sum of their sides	—	—	—	—	110 $\frac{1}{4}$ — 7.95703
Is to their difference	—	—	—	—	38 $\frac{1}{4}$ — 1.58433
So is the Tangent of	—	—	—	—	38 deg. 07 $\frac{1}{2}$ — 9.72706
To the Tangent of	—	—	—	—	10 deg. 32 min. — 9.26932

Which added together, make the Angle D F A 38 deg. 39 $\frac{1}{2}$ .

And seeing the Rhomb from F to D is East, and the Angle D F A 38 deg. 39 min  $\frac{1}{2}$ . therefore the Rhomb from F to A is to the Northwards of the East 38 deg. 39 min.  $\frac{1}{2}$ ; that is, N. E. by E. almost half a Point Northerly; which is the Rhomb from the second Port to the first.

*Lastly, for A F the distance of these two Ports.*

As the Sine of the Angle D F A $\angle$ 38 deg. 39 $\frac{1}{2}$	—	—	—	—	20434
To the Dead-Reckoning homewards	—	—	—	—	A D 74 $\frac{1}{4}$ Miles 1.87152
So the Sine of the Angle D $\angle$ 56 deg. 14 min.	—	—	—	—	9.91985



Thus the true distance of those two Ports is 99 Miles, and somewhat more.

Sundry other Questions of like nature might be purposed, which to him that well understandeth, these will not be difficult.

These Principles a little enlarged, may further with a few Experiments be applied in the discovery of some Mysteries in compound motions, not yet divulged, tho much endeavoured by sundry famous Men in several parts of *Europe*; but these we shall not touch at present.

12. *To find where there is a Current at Sea; also which way it sets, and how fast.*

This may be done by comparing the Reckonings outwards with the Reckonings homewards, whereof we shall give an Example or two.

First, Admit a Ship sail from a certain Port, by one or several Rhombs or Distances, till she arrive at the second, and there find, reckoning by Course and Distance, that she is more Southerly than the Port from which she departed by 541 Miles, and more Westerly by 145 Miles: But by the Reckoning homewards, when he arrives again at the first place, he finds himself to the Northwards of the second 541 miles, as before, and to the Eastwards 305 miles. Now supposing he was 3 days outward bound, and 5 days homewards bound, I would know which way the Current sets, and how fast? Here, because the Easterly Distance homewards is greater than the Westerly Distance outwards, therefore from the Easterly Distance 305 miles, subtract the Westerly Distance 145 miles, the remainder being 160 miles, is the motion of the Current to the Westwards.

And thus it appears, that the Current sets to the Westwards, 160 miles in 8 days, that is, 20 miles a day, or  $\frac{2}{3}$  of a mile every hour.

2 *Example.* Admit a Ship sail from the *Summer Islands*, by several Rhombs and Distances, till she arrive at Cape Codd in *New-England*, namely, from the East part of *Summer-Islands*, (the Variation being allowed) first, North 20 miles, and then N. N. W. 150 miles; the second day N. by W. 180 miles; the third day North 90 miles; the fourth day North-East 88 miles, and so arrive at Cape Codd: Then by these Courses and Distances we may gather by the foregoing Table, that Cape Codd should by this Reckoning be to the Northwards 487 miles; and to the Westwards 30 miles, as here appears.



	North.	South.	East.	West.
North 20 Miles	20 0			
North North-West 150 Miles	123 6			57 4
North by West 180 Miles	176 5			35 1
North 90 Miles	90 0			
North East 88 Miles	62 2		62 2	
528 Miles	487 3		62 2	92 5
				62 2
				30 3

Now suppose the sail back again from Cape Codd towards the *Summer-Islands*, the first day S. S. W. 150 miles, the second day S. S. W. 160 miles, the third day S. by W. 130 miles, the fourth day South 140 miles, the fifth day East 110 miles, and so be come again to the East part of the *Summer-Islands*.

	North.	South.	East.	West.
South W. 150 Miles		138. 6		57. 4
South S. W. 160 Miles		147. 8		61. 3
South by W. 130 Miles		127. 5		25. 3
South 140 Miles		140. 0		
East 110 Miles			110. 0	
690 Miles.		554. 0	110. 0	144. 0
				110. 0
				34. 0

These Courses and Distances make, as here appeareth, the *Summer-Islands* to be to the Southwards of Cape Codd 554 Miles, and to the Westwards 30 Miles.

Therefore by this last Reckoning back again, Cape Codd should be to the Eastwards of the *Summer-Islands* 554 Miles, and to the Eastwards 34 Miles, whereas by the former Reckoning outwards 30 Miles; so that the difference of these two Reckonings outwards and back again, is 67 Miles Northerly, and 64 Miles Easterly; which sheweth that the Current in that time, namely, in nine days, hath set to the Northwards 67 Miles, and to the Eastwards 64 Miles; that is, North-East a little Northerly, 93 Miles, as by the foregoing Table doth appear, which is  $10\frac{1}{3}$  Miles every day.

And what we have here done by the Table, might have been done (as the foregoing Problems) by the *Doctrine of Plain Triangles*.

F I N I S.



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